INSTRUCTION MANUAL

TF 1530
TF 1530
210-0119

TYPE
RM 504
OSCILLOSCOPE
TF 1530

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

INSTRUCTION MANUAL

Serial Number 2626

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-315

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

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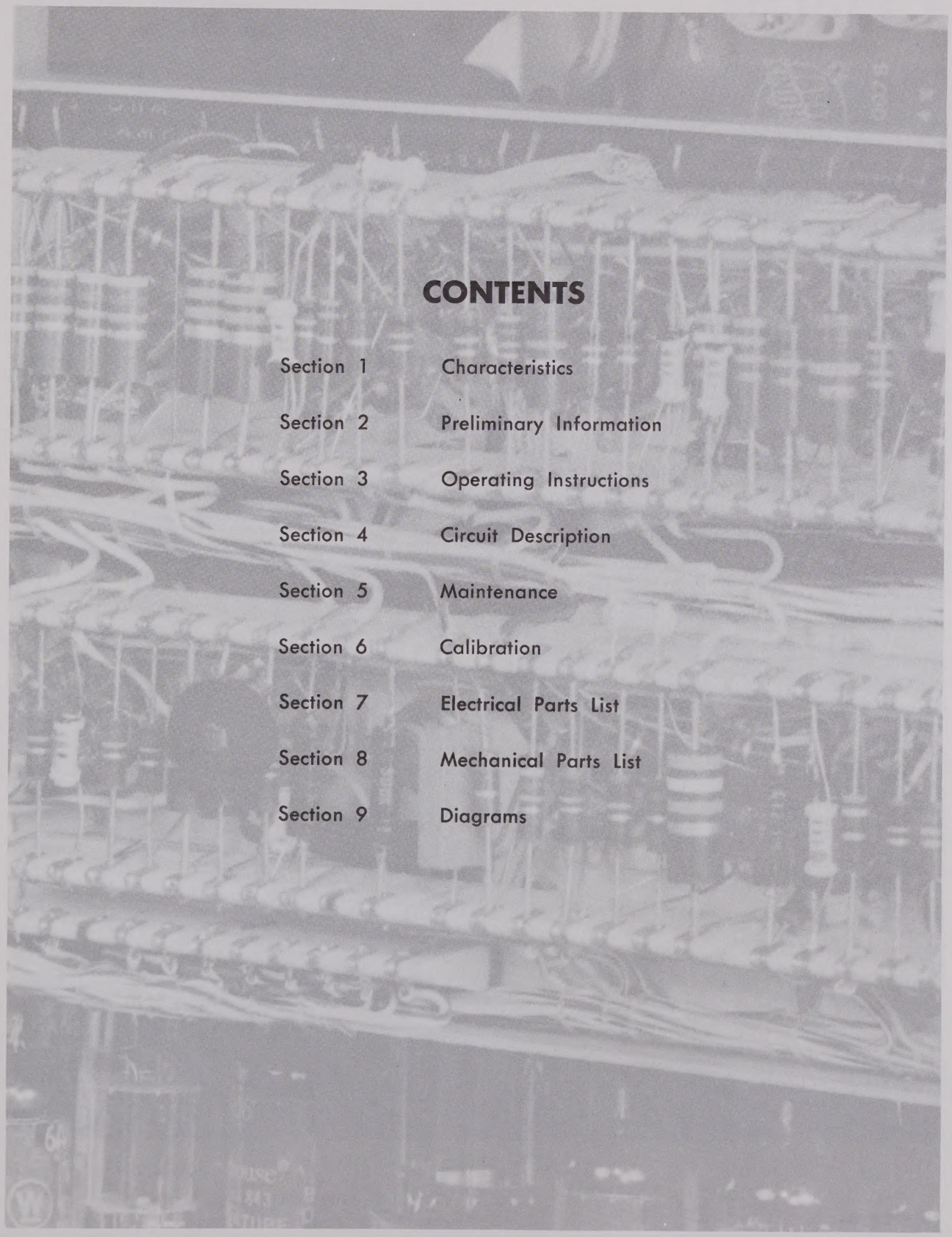

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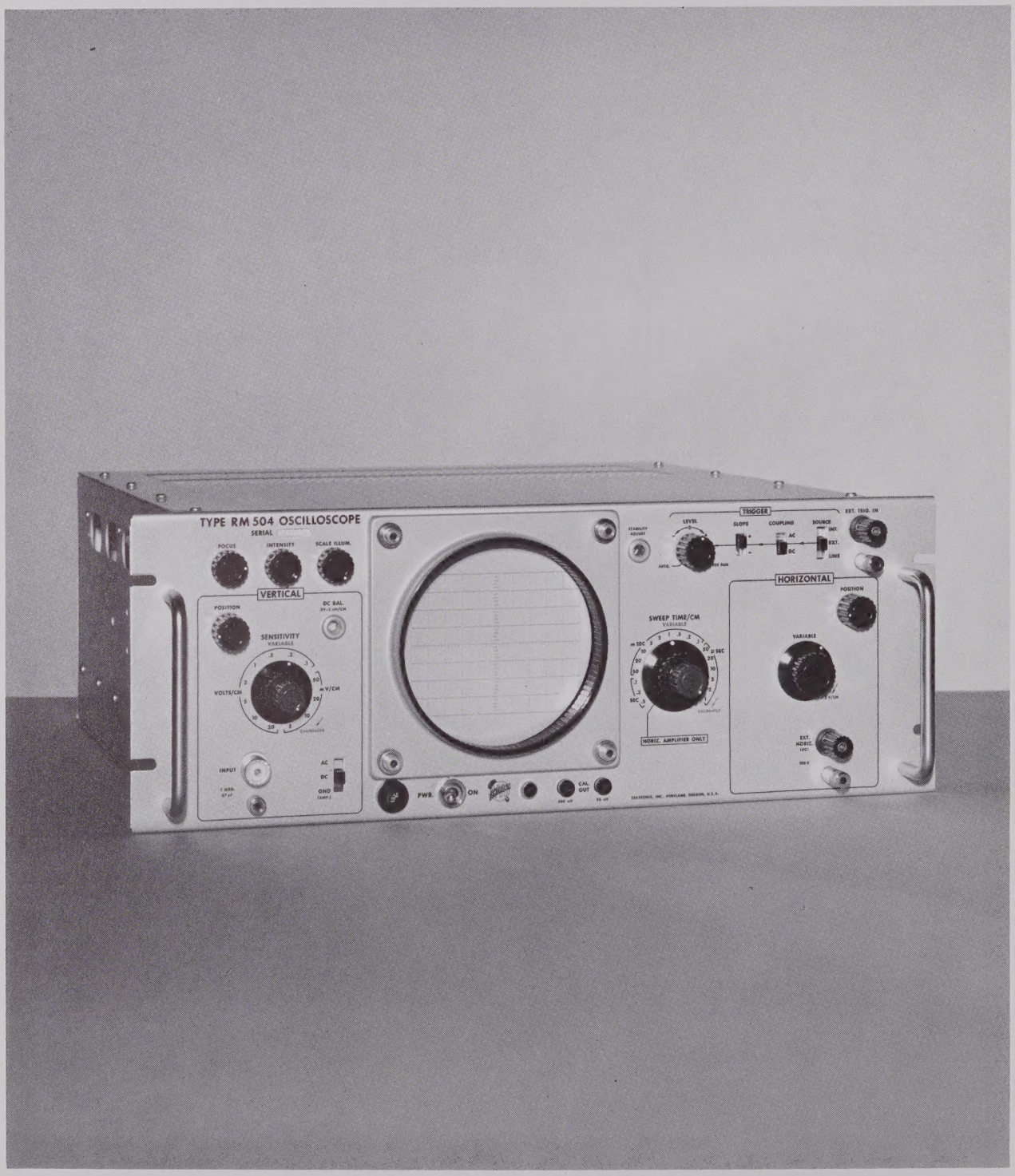
TYPE RM 504 OSCILLOSCOPE
SERIAL
FOCUS
INTENSITY
SCALE ILLUM.
VERTICAL
POSITION
DC BAL.
SENSITIVITY
VARIABLE
VOLTS/CM
mV/CM
INPUT
AC
DC
GND
TRIGGER
LEVEL
SLOPE
COUPLING
SOURCE
EXT. TRIG. IN
HORIZONTAL
POSITION
SWEEP TIME/CM
VARIABLE
HORIZ. AMPLIFIER ONLY
EXT. HORIZ.
PWR.
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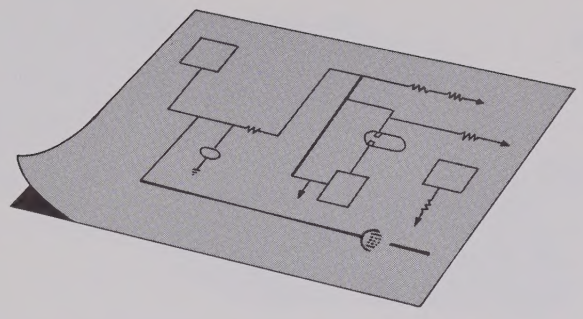
CAL. OUT



SECTION 1

CHARACTERISTICS

Introduction

The Tektronix Type RM504 Oscilloscope is a low-frequency, high-sensitivity laboratory instrument providing accurate time and amplitude measurements in the range from dc to 450 kc. Its high reliability, stability, simple operation, and light weight make it adaptable as a general purpose laboratory instrument.

Vertical Deflection System

Input Impedance—1 megohm paralleled by 47 $\mu\mu$f.

Coupling—AC or DC.

Deflection Factors—Twelve calibrated deflection factors from 5 millivolts per centimeter to 20 volts per centimeter, accurate within 3%.

Bandpass—DC to 450 kc (vertical response down 3 db or less at 450 kc).

Triggering

Type—Automatic, or amplitude-level selection using preset stability.

Coupling—AC.

Slope—Plus, from positive slope of triggering waveform, or minus, from negative slope of triggering waveform.

Source—Internal from vertical signal, external from triggering signal, or line from 60 cps.

Signal Requirements—Internal: signal producing 0.5 centimeter or more vertical deflection on crt screen.

External: 0.5 volt to 10 volts, peak. (Sweep will trigger on larger external signals, but LEVEL control operates over ±10-volt range).

Sweep

Type—Miller Integrator.

Rates—Eighteen calibrated sweep rates from 1 microsecond per centimeter to 0.5 second per centimeter.

Accuracy typically within 1% of the indicated sweep rate; in all cases within 3%.

External Horizontal Input

Sensitivity—0.5 volt per centimeter maximum.

Input Resistance-100 kilohms.

Amplitude Calibrator

Waveform—Square waves at approximately 350 cps.

Amplitude—25 millivolts and 500 millivolts, peak-to-peak.

Cathode-Ray Tube

Type T503P

Phosphor—Type P2 normally furnished; P1 and P11 phosphors optional. Other phosphors available on special order.

Accelerating Potential—3000 volts.

Z-Axis Modulation—External terminal permits RC coupling to crt grid.

Graticule

Illumination—Variable edge lighting.

Display Area—Marked in 8 vertical and 10 horizontal 1-centimeter divisions, with 2-millimeter markings on the centerlines.

Power Supplies

Electronically regulated for stable operation with widely varying line voltages and loads.

Line Voltage Requirements—105 to 125 volts, or 210 to 250 volts, rms, 50-60 cycles.

Will operate at line frequencies to 800 cps with higher line voltages (see Section 2).

Power Requirements—Approximately 110 watts.

Mechanical Specifications

Construction—Aluminum alloy chassis and cabinet.

Finish—Anodized panel, aluminum cabinet.

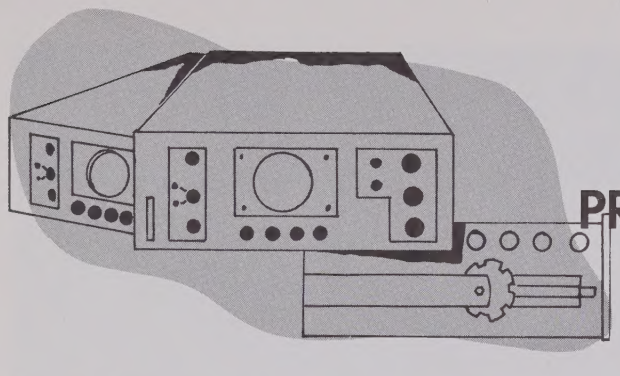
Dimensions—7" high, 19" wide, 16½" deep (additional depth of 3" required for power cord).

Weight—25 pounds.

Accessories

Information on accessories for use with this instrument is included at the rear of the mechanical parts list.

NOTES



SECTION 2

PRELIMINARY INFORMATION

Power Requirements

The Type RM504 Oscilloscope line transformer primary can be wired for either 117-volt or 234-volt operation at a line frequency of 50 to 800 cps. At this frequency, proper regulation of the power supply will be obtained at voltages between 105 and 125 volts when the transformer is wired for 117-volt operation, and between 210 and 250 volts when the transformer is wired for 234-volt operation. Fig. 2-1 shows the transformer connections required for each range of operation.

The Type RM504 Oscilloscope can be operated at any ac line frequency from 50 cps to 800 cps although higher line voltages are required at the higher frequencies. At an ac line frequency of 400 cps, the nominal and lower and upper limits are about 10% higher than at 50 to 60 cps. At an ac line frequency of 800 cps, the nominal and lower and upper limits are about 15% higher than at 50 to 60 cycles. At frequencies between the specific values given, the required voltages will be proportionately large or smaller. For maximum dependability and longest life, it is recommended that the line voltage be kept at or slightly below the nominal.

Fuse Requirements

A 1.25-amp slow-blowing type fuse should be used when the Type RM504 is wired for 117-volt operation. A 0.8-amp slow-blowing type fuse should be used when the Type RM504 is wired for 234-volt operation.

Rack Mounting

The Type RM504 is ready for mounting in a standard 19-inch open or enclosed relay rack.

To mount the instrument directly to either type of rack, first select four screws from the hardware kit whose threads match the threads of the mounting holes in the rack. Align the slots at the sides of the front panel with the holes in the rack, at the desired height. Fasten the instrument to the rack with four mounting screws, cup washers, and plastic washers. The plastic washers are inserted between the cup washers and the front panel to prevent the cup washers from cutting into the front panel when the screws are tightened.

Removal of Top and Bottom Panels

The top and bottom panels of the Type RM504 Oscilloscope are held in place by small flat-head screws. To remove the panels, first remove the screws. Then slide the panels back and lift free of the instrument. The panels can be replaced by reversing the order of their removal.

Thermal Cutout

A thermal cutout switch in the primary circuit of the power transformer, T601, protects the Type RM504 from overheating. If the internal temperature rises above the rating of the thermal switch, the switch will disconnect the power and keep it disconnected until the temperature drops to a safe value.

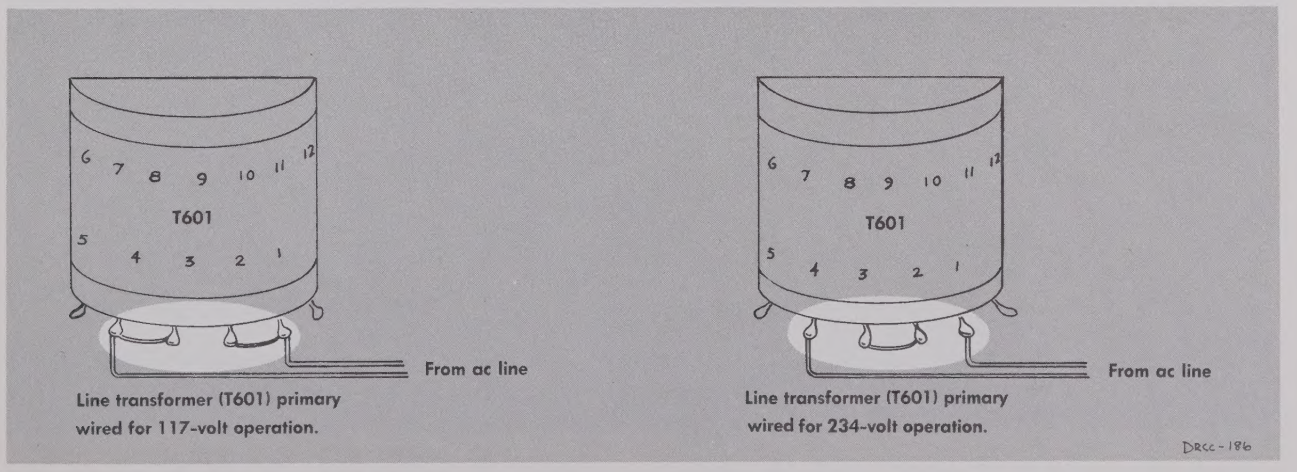

6 7 8 9 10 11 12
T601
5 4 3 2 1
From ac line
Line transformer (T601) primary wired for 117-volt operation.
6 7 8 9 10 11 12
T601
5 4 3 2 1
From ac line
Line transformer (T601) primary wired for 234-volt operation.
DRCC-186

Fig. 2-1. Line transformer wired for 117- and 234-volt operation.

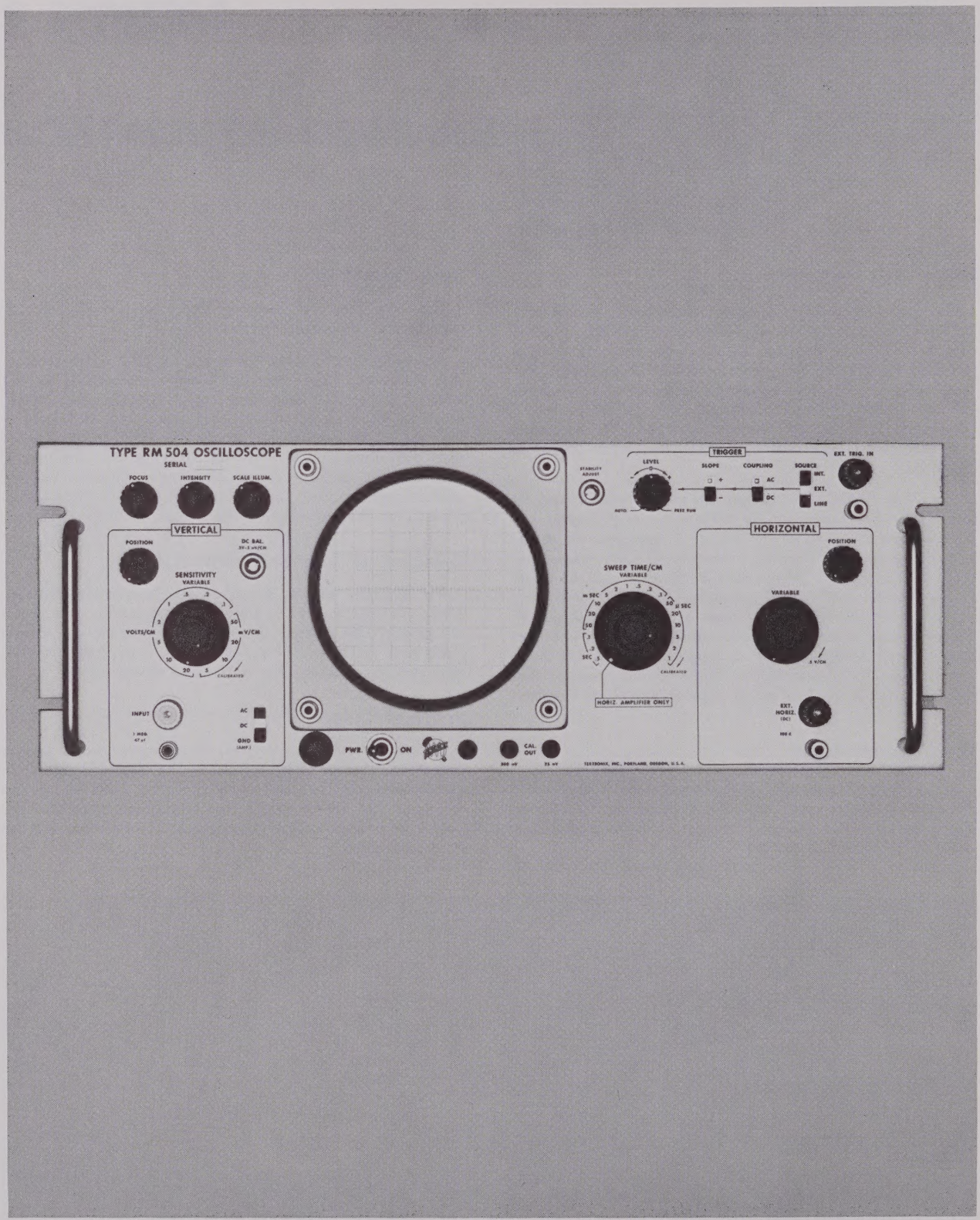
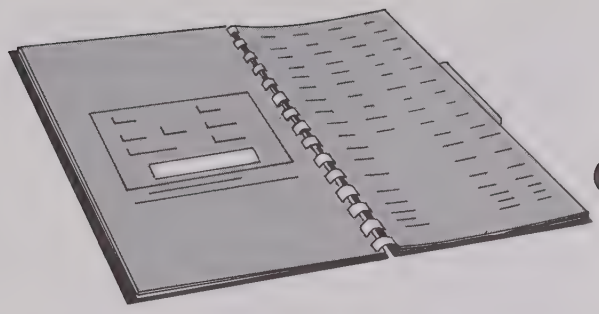


Fig. 3-1. Type RM504 Oscilloscope Front Panel.



SECTION 3

OPERATING INSTRUCTIONS

FRONT-PANEL CONTROLS AND CONNECTORS

The front panel of the Type RM504 Oscilloscope is shown in Fig. 3-1. Functons of all front-panel controls and connectors are described in Table 3-1.

TABLE 3-1

SLOPE	Selects whether triggering occurs on positive-going portion (+slope) or negative-going portion (—slope) of triggering signal.
COUPLING	Selects whether triggering occurs at a specific dc level or at an ac level.
SOURCE	Selects the source of the triggering signal.
EXTERNAL TRIG. IN connector	Input connector for external triggering signal.
LEVEL	Selects the voltage point on the triggering signal at which the horizontal sweep is triggered. This control also selects automatic triggering (AUTO. position) or allows the sweep to free run (FREE RUN position).
STABILITY ADJUST	Provides for stable presentation with proper setting of LEVEL control.
SWEEP TIME/CM	Selects the desired horizontal sweep rate from a choice of 18 calibrated steps; or provides for application of external signal to Horizontal Amplifier (HORIZ. AMPLIFIER ONLY position).
SWEEP TIME/CM VARIABLE (Red knob)	Provides for a continuous range of sweep rates between the fixed steps selected by the SWEEP TIME/CM control. Normally, sweep rates are calibrated only when the VARIABLE control is set to the CALIBRATED position (fully clockwise until it snaps into position).
FOCUS	Focuses the spot or trace on the screen.
INTENSITY	Controls the brightness of the spot or trace on the screen.
SCALE ILLUM	Controls graticule illumination.
CAL. OUT connectors	Provide amplitude-calibrated square waves of 25 and 500 millivolts for use in calibrating gain of amplifiers.
VERTICAL POSITION	Controls vertical positioning of the display on the screen.
SENSITIVITY	Selects the sensitivity of the Vertical Amplifier from 12 calibrated steps.
SENSITIVITY VARIABLE (Red knob)	Provides a continuous range of sensitivity values between the fixed calibrated steps selected by the SENSITIVITY control. Normally, sensitivity is calibrated only when VARIABLE control is set to the CALIBRATED position (fully clockwise until it snaps into position).
DC BAL.	Provides for vertical stability of no-signal trace for all positions of the SENSITIVITY control.
INPUT connector	Input connector for signal to be displayed vertically.
AC-DC-GND	Selects desired coupling for incoming signal, or grounds input circuit of Vertical Amplifier.
HORIZONTAL VARIABLE	Controls attenuation of signal applied to EXT. HORIZ. connector.
HORIZONTAL POSITION	Controls horizontal positioning of the display on the screen.
EXT. HORIZ. connector.	Input connector for signal to be displayed horizontally.
PWR-ON	Applies and shuts off line power to the instrument.

PRELIMINARY INSTRUCTIONS

To initially set up the Type RM504 Oscilloscope for operation, proceed as follows:

1. Connect the oscilloscope to a suitable source of power (as described in Section 2 of this manual) and turn the POWER switch on.

Set the INTENSITY control fully counterclockwise. Let the instrument warm up for about 5 minutes.

2. Set all front panel controls to the positions shown in Fig. 3-1. Make sure that both red VARIABLE controls are set to the CALIBRATED position (fully clockwise until they snap into position).

3. Adjust the FOCUS control for the most sharply defined trace.

4. Note the vertical position of the trace on the screen.

5. Set the SENSITIVITY control to the 5mV/CM position.

6. Adjust the DC BAL. control to bring the trace back to where it was in step 4.

7. Continue adjusting the DC BAL. control so that the trace does not move vertically as the SENSITIVITY control is moved between the .2 VOLTS/CM position and the 5mV/CM position.

The Vertical Amplifier is now balanced and the oscilloscope is ready for operation as described in the remainder of this section.

Graticule Illumination

Graticule illumination can be adjusted to suit the lighting conditions of the room by means of the SCALE ILLUM. control. Turning the control clockwise increases the graticule illumination. It is possible to extinguish the graticule illumination completely by turning the control fully counterclockwise.

The graticule of the Type RM504 Oscilloscope can be illuminated so that it appears to have either red or white graticule markings. The markings can be changed from white to red or red to white simply by removing the graticule cover and inverting the graticule. As a general rule, white graticule lines are superior to red for photographic purposes.

INPUT COUPLING

The signal to be displayed on the crt screen is connected to the INPUT connector, preferably by means of a coaxial cable. The signal may be either ac or dc coupled by placing the AC-DC-GND switch in the appropriate position. Setting the AC-DC-GND switch to DC applies both the ac and dc components of the signal to the amplifier circuits. This permits you to measure the dc voltage level as well as the amplitude of the ac component. However, it is sometimes neither necessary nor desirable to display the dc component, and in such cases ac coupling should be used. Setting the AC-DC-GND switch to AC places a capacitor in series with the INPUT connector to block the dc component while allowing the ac component to be displayed. Placing the AC-DC-GND switch in the GND position grounds the input circuit of the Vertical Amplifier to provide a ground reference point from which to measure dc voltages.

Certain precautions must be observed in connecting the oscilloscope to the signal source to prevent errors due to stray electric or magnetic coupling in the leads. Shielded cables should be used whenever possible, with the shield connected to the chassis of both the oscilloscope and the signal source. Regardless of the type of input lead used, it should be kept as short as possible.

In broadband applications, it might be necessary to terminate a coaxial input cable with a resistor or an attenuating pad which presents a resistance equal to the characteristic impedance of the cable. This is to prevent resonance effects and "ringing" (high-frequency damped oscillation). It becomes more necessary to terminate the cable properly as the length of the cable is increased. The termination is generally placed at the oscilloscope end of the cable, although many sources require an additional termination at the source end of the cable as well.

Also, to reduce the loading effects of the oscilloscope on the equipment being tested, it may be desirable to use an attenuator probe which will present a greater input impedance to the signal source.

USE OF PROBES

Use of an attenuator probe with the RM504 will reduce the capacitive and resistive loading on a circuit under test, but at the same time will also reduce the sensitivity.

Connected to the VERTICAL INPUT connector of the Type RM504, a Tektronix probe presents a characteristic impedance of 10 megohms paralleled by from 8 to 14 $\mu\mu$f (depending on the probe) and has an attenuation of 10:1. The maximum voltage rating of a Tektronix probe is 600 volts. Exceeding this rating, either in dc volts or peak ac volts, may damage the probe.

While making amplitude measurements with an attenuator probe, be sure to multiply the observed amplitude on the crt by the attenuation factor of the probe. If the waveform being displayed contains fast-changing signals, it will generally be necessary to clip the probe ground lead to the chassis of the equipment under test.

Probe Compensation

An adjustable capacitor in all Tektronix probes is used to compensate for variations in input capacitance from one instrument to another. To insure the accuracy of pulse and transient measurements, always check the compensation before using a probe.

To check or adjust the probe compensation, display several cycles of the Calibrator waveform on the crt by connecting a test land between the 500 mv CAL. OUT connector and the VERTICAL INPUT connector. For this display set the SENSITIVITY control to .1 VOLTS/CM and the AC-DC-GND switch to DC.

Carefully observe the waveform display on the crt, and particularly note the general shape of the leading corners of the positive pulses. Then disconnect the test lead between the CAL. OUT and INPUT connectors, and connect the probe cable to the INPUT connector. Set the SENSITIVITY control to 10 mV/CM and touch the probe tip to the 500 mV CAL. OUT connector. Square waves having the same amplitude as those in the previous display should now appear on the crt. Carefully adjust the probe capacitance, if necessary, until the leading corners of the positive pulses have the same shape as those in the previous display.

SWEEP OPERATION

The Type RM504 Oscilloscope allows you to select, with the SWEEP TIME/CM control, any one of 18 calibrated sweep rates ranging, in steps, from 1 microsecond per centimeter to 0.5 second per centimeter. The SWEEP TIME/CM VARIABLE control (red knob) makes it possible to obtain a continuous range of sweep rates between the steps selected by the

SWEEP TIME/CM control; however, all sweep rates obtained with the SWEEP TIME/CM VARIABLE control not in the CALIBRATED position are uncalibrated. Setting the SWEEP TIME/CM control to the HORIZ. AMPLIFIER ONLY position permits the use of the oscilloscope in the X-Y mode, with external signals applied to both the Vertical and Horizontal Amplifiers. Operation in the X-Y mode is discussed later in this section.

Sweep Triggering

In order to obtain a stable display, it is necessary to start the horizontal sweep consistently at the same time relative to recurring cycles of the input signal. The sweep therefore must be triggered by the input signal itself, or by some signal which bears a fixed time relationship to the input signal. The following instructions tell you how to select and use the proper triggering signal for various applications of the oscilloscope.

Selecting the Trigger Source

For most applications the sweep can be triggered by the input signal. The only requirement is that the input signal be large enough to provide at least 0.5 centimeter of deflection on the screen at the sensitivity level for which the SENSITIVITY control is set. To obtain triggering of the sweep from the input signal, set the SOURCE switch to INT.

Sometimes it is advantageous to trigger the sweep with some external signal. This is especially true when the input waveform is of such small amplitude that it cannot provide stable triggering of the sweep by itself. The Type RM504 Oscilloscope will trigger properly on an external triggering signal of 0.5 volt or more. External triggering signals over 10 volts in amplitude should not be used as they will overdrive the Trigger Input Amplifier. External triggering is also useful where waveforms are going to be sampled from several different places within a device. By using external triggering it is not necessary to reset the triggering controls each time a new waveform is shown. In order to obtain a stable display, it is necessary that the external triggering signal bear a fixed relationship to the input signal. To use an external signal for triggering the horizontal sweep, connect the signal to the EXTERNAL TRIG. IN connector and set the SOURCE switch to EXT.

When you are observing a waveform which bears a fixed time relationship to the ac line frequency, you may wish to trigger the sweep from the line-frequency waveform. To do this, place the SOURCE switch to LINE.

Selecting the Trigger Coupling

For most recurrent waveforms, ac coupling of the triggering signal (COUPLING switch in the AC position) will provide satisfactory triggering of the sweep. DC coupling of the triggering signal (COUPLING switch in the DC position) is particularly useful in triggering from random pulse trains or very low frequency signals. With dc coupling the sweep is triggered by an instantaneous dc voltage. With ac coupling the sweep is triggered when the signal reaches a given amplitude from its average dc level.

Selecting the Trigger Slope

When the SLOPE switch is in the + position, the sweep is triggered on a positive slope of the triggering signal. When the SLOPE switch in the — position, the sweep is triggered on a negative slope of the triggering signal. In most cases, selection of the triggering slope is not critical since triggering on either slope will usually provide a display which is suitable.

Selecting the Trigger Level

The LEVEL control determines the instantaneous voltage level (ac or dc, depending upon the setting of the COUPLING switch) on the triggering signal at which the sweep is triggered. Moving the LEVEL control clockwise causes triggering to occur on a more positive point of the triggering signal; moving it counterclockwise causes triggering to occur on a more negative point of the triggering signal. So it can be seen that, with proper settings of the SLOPE switch and the LEVEL control, triggering can be made to occur at virtually any point on a positive or negative slope of the triggering signal. The effects of these two controls are illustrated in Fig. 3-2.

At the extreme counterclockwise and clockwise ends of its range, the LEVEL swtich activates, respectively, the AUTO. and FREE RUN switches. The effects of these switches are discussed in the following paragraphs.

Automatic Mode of Triggering

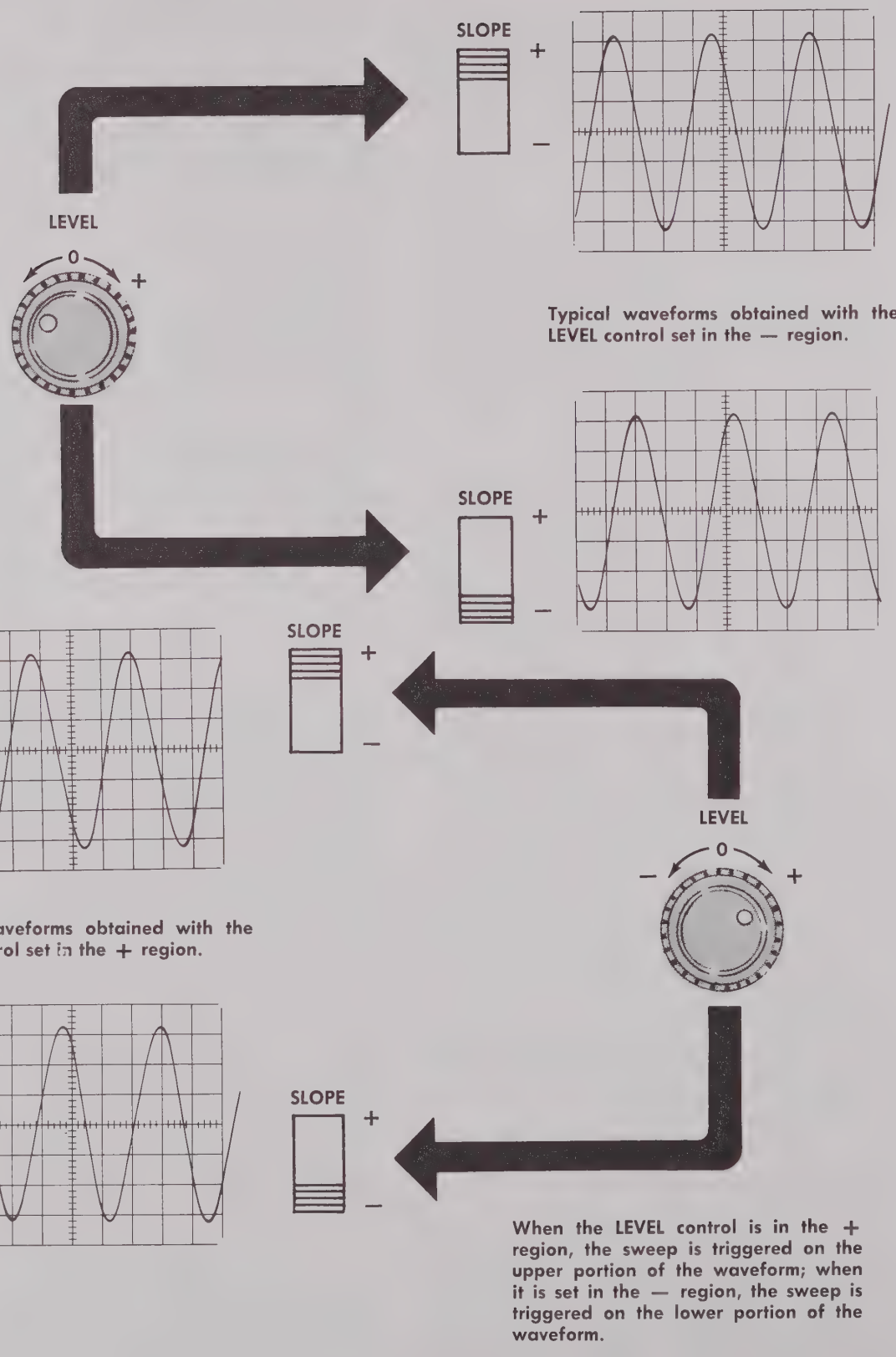
Setting the LEVEL contro fully counterclockwise to the AUTO. position sets the Type RM504 Oscilloscope up for an automatic mode of triggering which is suitable for most applications. In this mode, the triggering signal is ac coupled, and the triggering level is automatically set such that any external signal of one volt or more, or internal signal which would produce one centimeter or more of deflection on the crt screen, will trigger the sweep. In the absence of such a triggering signal, the sweep will continue to be triggered automatically at about a 50-cps rate. This produces a base line which indicates that the instrument is adjusted to display any signal which might be connected to the INPUT connector. This base line can also be used as a reference from which to make dc measurements when the input signal is dc coupled.

Free-Running Mode of Triggering

Setting the LEVEL control fully clockwise to the FREE RUN position produces a free-running sweep, independent of any synchronizing signal. The frequency of the free-running sweep is dependent upon the setting of the SWEEP TIME/CM control.

X-Y MODE OF OPERATION

Placing the SWEEP TIME/CM control in the HORIZ. AMPLIFIER ONLY position disables the Sweep Generator and sets the Type RM504 Oscilloscope up for X-Y operation. In this mode of operation, input signals are normally applied to both the INPUT connector and the EXT. HORIZ. connector.



Typical waveforms obtained with the LEVEL control set in the — region.

Typical waveforms obtained with the LEVEL control set in the + region.

When the LEVEL control is in the + region, the sweep is triggered on the upper portion of the waveform; when it is set in the — region, the sweep is triggered on the lower portion of the waveform.

Fig 3-2. Effects of SLOPE switch and LEVEL control.

The display is a graph of one signal versus the other. The Horizontal Amplifier has a maximum sensitivity of 0.5 volt per centimeter of deflection with the HORIZONTAL VARIABLE control set fully clockwise. The sensitivity can be reduced by turning this control counterclockwise. Normally, the sensitivity is calibrated only when the control is set fully clockwise.

APPLICATIONS

The following paragraphs describe procedures for making measurements of voltage, elapsed-time, frequency, and phase difference with Type RM504 Oscilloscope. No attempt has been made to describe any but the most basic techniques. Familiarity with the instrument will enable the operator to apply the essence of these techniques to a wide variety of applications, depending upon the problem at hand.

Voltage Measurements

To measure the potential difference between two points on a signal, proceed as follows:

1. Apply the signal to the INPUT connector and set the AC-DC-GND switch to AC.

2. Set the TRIGGER controls for a stable display.

3. Display the waveform over as large a portion of the screen as possible by adjusting the SENSITIVITY control. Make sure that the SENSITIVITY VARIABLE control is in the CALIBRATED position.

4. With the aid of the graticule, measure the vertical distance, in centimeters, between the two points on the waveform between which the voltage measurement is desired. On small voltage measurements, the width of the trace can make up an appreciable part of the entire measurement. For this reason, it is important to take all readings in a given measurement from the same side of the trace.

5. Multiply the distance between the two points by the setting of the SENSITIVITY control and by the attenuation factor, if any, of the probe. This is the potential difference between the two points on the waveform. Note that this technique can be used to measure peak-to-peak ac voltages.

To measure the difference in potential between two points on a signal applied to the EXT. HORIZ. connector, measure the horizontal difference between the two points and multiply this distance by 0.5 volts per centimeter. This applies only if the HORIZONTAL VARIABLE control is set fully clockwise.

To measure the dc level at some point on a signal, proceed as follows:

1. Apply the signal to the INPUT connector and set the AC-DC-GND switch to GND.

2. Set the LEVEL control to AUTO.

3. With the VERTICAL POSITION control, position the trace so that it lies along one of the lines of the graticule. This line will be used as a ground reference line; its position in any given case will depend upon the polarity and amplitude of the input signal to be measured. Do not adjust the VERTICAL POSITION control after the reference line has been established.

4. Set the AC-DC-GND switch to DC. If necessary, adjust the LEVEL control for a stable display. If the waveform has moved off the screen, set the SENSITIVITY control to a higher setting (more counterclockwise) and repeat steps 3 and 4.

5. Measure the distance, in centimeters, from the ground reference line established in step 3 to the point at which the dc level is desired.

6. Multiply this distance by the setting of the SENSITIVITY control and the attenuation factor, if any, of the probe. This is the dc level of the point measured.

Elapsed-Time and Frequency Measurements

To measure the time interval between two points on a waveform, proceed as follows:

1. Apply the signal to the INPUT connector and set the oscilloscope controls so that a stable display is obtained.

2. With the aid of the graticule, measure the horizontal distance, in centimeters, between the two points whose time interval you wish to find. Make sure that the SWEEP TIME/CM VARIABLE control is in the CALIBRATED position. There is some tendency toward distortion at the extreme edges of the graticule. For this reason, you should use only the center eight centimeters of graticule width for most accurate measuring. See Fig. 6-5.

3. Multiply the distance measured by the setting of the SWEEP TIME/CM control. This is the time interval between the two points measured.

To determine the frequency of a recurrent waveform, simply take the reciprocal of the time interval between corresponding points on two consecutive cycles of the waveform.

Phase-Difference Measurements

To measure the phase difference between two signals of the same frequency, proceed as follows:

1. Set the oscilloscope up for external triggered operation with one of the signals applied to the INPUT connector.

2. Horizontally position the display so that an easily identifiable point of a cycle coincides with one of the vertical graticule lines.

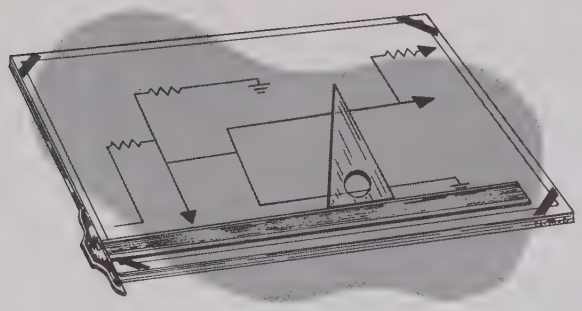
3. Without making any adjustments to the oscilloscope, disconnect the first signal and apply the second signal to the INPUT connector. (Normally, this can be done simply by moving the probe from one signal source to the other.) If there is a phase difference between the two signals, you will find that the display has shifted horizontally.

4. Measure the amount of horizontal shift of the display in centimeters.

5. Measure the distance in centimeters between corresponding points on two consecutive cycles of the waveform.

6. Divide the measurement obtained in step 4 by the measurement obtained in step 5 and multiply the result by 360°. This is the phase difference between the two signals.

NOTES



SECTION 4

CIRCUIT DESCRIPTION

A block diagram of the Type RM504 Oscilloscope is shown in Fig. 4-1. In general, the operation of the instrument is as follows:

The signal to be displayed is amplified by the Vertical Amplifier and applied push-pull to the vertical deflection plates of the crt. A portion of the signal is "tapped off" in the Vertical Amplifier and applied to the Sweep Trigger as a triggering signal. Provisions are also made for applying an external signal or the ac line waveform, as desired, to the Sweep Trigger as a triggering signal. The Sweep Trigger generates a negative trigger pulse coincident with a selected point on each cycle of the triggering signal. The negative trigger pulse triggers the Sweep Generator which generates a positive-going sawtooth waveform. This sawtooth waveform is amplified by the Horizontal Amplifier and applied push-pull to the horizontal deflection plates to sweep the electron beam across the screen. If desired, the Sweep Generator can be disabled and an external signal applied directly through the Horizontal Amplifier to the horizontal deflection plates.

The Calibrator generates amplitude-calibrated square waves 25 millivolts and 500 millivolts amplitude primarily for use in calibrating the gain of the Vertical Amplifier. The Power Supply supplies the regulated voltages and currents necessary for proper operation.

The remainder of this section discusses the operation of each of the circuits of the Type RM504 Oscilloscope in detail. During these discussions, you should refer to the circuit diagrams contained in the Parts List and Schematic Diagrams section of this manual.

VERTICAL AMPLIFIER

General Description

The Vertical Amplifier consists basically of a two-stage Input Amplifier and a single-stage Output Amplifier. The maximum overall gain of the Vertical Amplifier is on the order of 4400 which provides the required 22 volts per centimeter of vertical deflection at the crt for each 5 millivolts of signal at the input (with the SENSITIVITY control in the 5 mV/CM position).

The first stage of the Input Amplifier is a cathode-coupled paraphase amplifier which converts the single-ended input to push-pull output. The second stage is a pair of transistors operated push-pull. The output from the Input Amplifier drives the Output Amplifier, which, in turn drives the crt vertical deflection plates. Step changes in Vertical Amplifier sensitivity are accomplished by changes in input attenuation and negative feedback in the Input Amplifier. Vernier sensitivity control is accomplished by degeneration in the cathode circuit of the Output Amplifier.

Input Circuit

The Input Switch, SW410, permits the input to the Vertical Amplifier to be either ac or dc coupled, or to be grounded. The lower bandpass limit of the input circuit when ac coupled is about 7.5 cps.

The signal at the input connector is applied either "straight through" or through either of two attenuators to the grid circuit of V434B. One of the attenuators attenuates the signal by a factor of 10, the other attenuates it by a factor of 100. These attenuators, combined with changes in resistance in the cathode circuit of the first stage of the Input Amplifier, provide the means of varying the effective sensitivity of the Vertical Amplifier, in steps, between 5 millivolts and 20 volts per centimeter of deflection.

The attenuators are both resistance and capacitance dividers which provide constant attenuation of the signal throughout the frequency range of the instrument. In addition to providing the proper degree of attenuation, the resistance and capacitance values of the attenuators are chosen or adjusted to provide a constant 1-megohm input resistance and 47-$\mu\mu$f input capacitance regardless of the setting of the SENSITIVITY control.

Input Amplifier

The gain of the Input Amplifier is varied (in steps) by changing the value of R408 in the cathode circuit of the first stage. This varies the amount of negative feedback applied to the first stage from the output of the second. This feedback is applied through R457 and R467 to the parallel network of R419 and L419 in series and R408. As the value of R408 is increased, the amount of the negative feedback voltage is increased, limiting the gain of the amplifier.

The DC BAL. control in the grid circuit of V434A provides the means of setting the potential of the cathode of V434A equal to the potential of the cathode of V434B when there is no input signal, so that there is no current through R408. This provides vertical stability of the no-signal trace as the value of R408 is changed by the SENSITIVITY control.

The second stage of the Input Amplifier is provided with a positive feedback path from the collector of each side to the base of the other. The amount of positive feedback is adjusted by varying the value of R460, which varies the gain of the stage. The overall negative feedback through

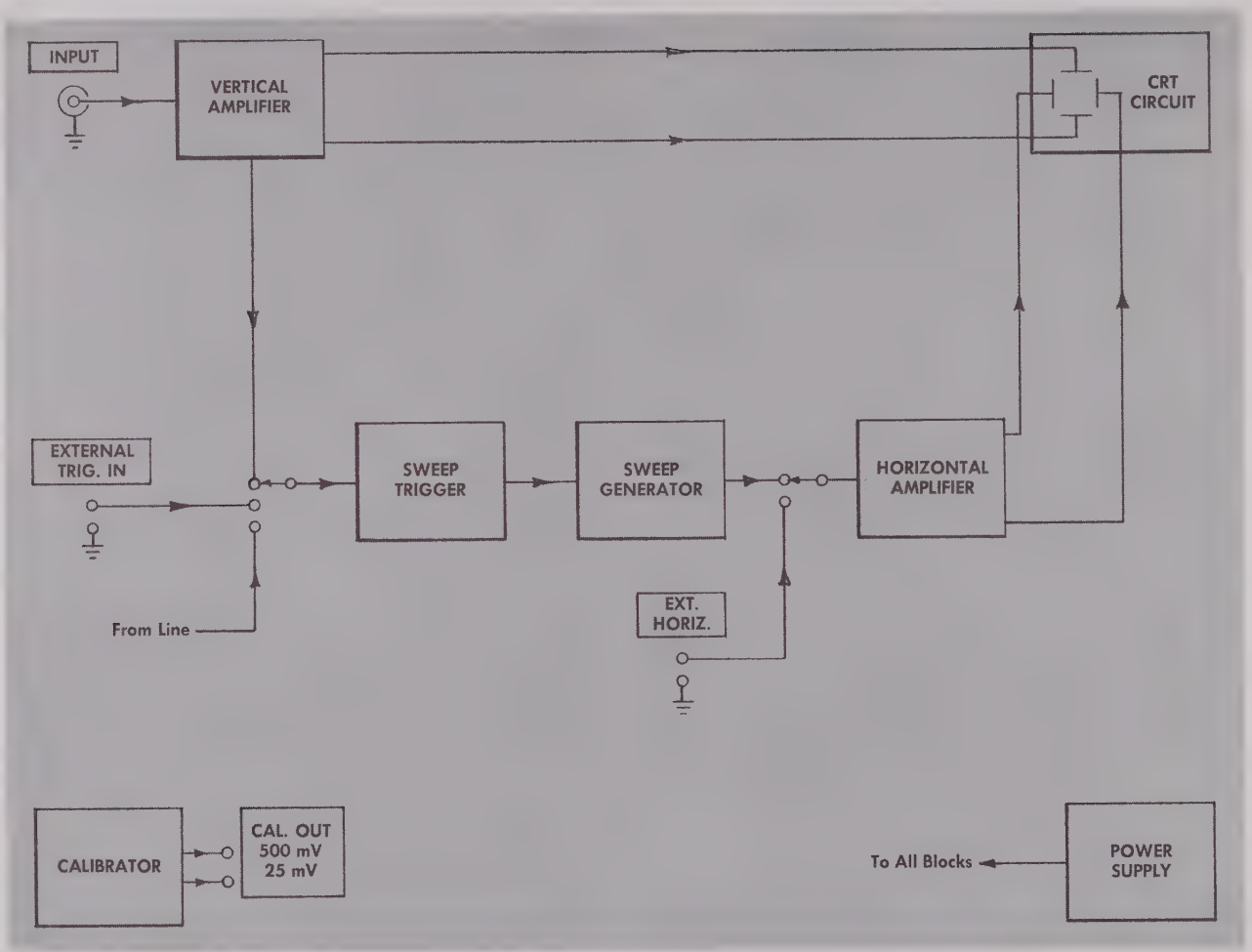


Fig. 4-1. Type RM504 simplified block diagram.

the first stage of the amplifier prevents the second stage from oscillating. The effect of R460 is most pronounced in the 5 mV/CM position of the SENSITIVITY control since there is the least amount of overall negative feedback in this position.

Output Amplifier

The gain of the Output Amplifier is adjusted by means of the .2V GAIN ADJ., R478, and the VARIABLE control, R488. Vertical positioning of the crt beam is accomplished by means of the cross-coupled dual POSITION potentiometer, R470. Adjustment of this control varies the current through the Output Amplifier tubes, thereby changing the average dc voltage at each of the plates inversely to the other. At the same time, through feedback in the Input Amplifier, the control also produces a small push-pull change in voltage at the grids of the Output Amplifier to maintain the cathodes at the same potential as the current is changed.

Trigger Pickoff

Part of the output from one side of the Output Amplifier is applied through a divider network to the SOURCE switch, SW5, in the Sweep Trigger. Thus, when the SOURCE switch is in the INT. position, a part of the displayed signal is applied to the Sweep Trigger to start the horizontal sweep.

SWEEP TRIGGER

The Sweep Trigger consists basically of the Trigger Input Amplifier, V24, and the Trigger Multivibrator, V45. The Trigger Input Amplifier amplifies (and, when desired, inverts) the incoming triggering signal and applies it to the input grid of the Trigger Multivibrator. The Trigger Multivibrator is a Schmitt circuit which is switched from one state to the other by the signal at its input. Its square-wave output is differentiated to form negative and positive spikes. The negative spikes are applied to the Sweep Generator to start the sweep. The positive spikes are bypassed to the +250-volt supply through diode D44.

Trigger Input Amplifier

The input to the Trigger Input Amplifier, V24, may be selected from any of three sourecs by means of the SOURCE switch SW5. When the SOURCE switch is in the INT. position, the signal is obtained from the Trigger Pickoff circuit in the Vertical Amplifier. When the SOURCE switch is in the EXT. position, the signal may be obtained from an external source through the TRIGGER INPUT connector on the front panel. When the SOURCE switch is in the LINE position, the signal is obtained from one of the 6.3-volt secondary windings of the line transformer.

As will be seen later, the negative spike at the output of the Sweep Trigger occurs only when there is a negative-going signal at the input ot the Trigger Multivibrator (output of the Trigger Input Amplifier). However, it is desired to be able to start the sweep during either a positive-going or negative-going portion of the incoming triggering signal as seen at the input to the Trigger Input Amplifier. To accomplish this, the SLOPE switch SW20 provides the means for inverting or not inverting, as desired, the triggering signal in the Trigger Input Amplifier.

When the SLOPE switch is in the — position, the incoming triggering signal is applied to grid of V24A, and V24 is a cathode-coupled amplifier. Its output is in phase with its input. Thus, the negative-going portion of the signal at the input to the Trigger Multivibrator corresponds to the negative-going portion of the incoming triggering signal. So, the negative spike at the output of the Sweep Trigger will occur during a time when the triggering signal is moving in a negative direction.

When the SLOPE switch is in the + position, the incoming triggering signal is applied to the grid of V24B, and V24B acts as a plate-loaded amplifier. Its output is opposite in polarity to its input. Thus, the negative-going portion of the signal at input to the Trigger Multivibrator corresponds to the positive-going portion of the incoming triggering signal So, the negative spike at the output of the Sweep Trigger will occur during a time when the triggering signal is moving in a positive direction.

The LEVEL control, R17, varies the average dc level of the plate of V24B from about +70 volts to +130 volts. This is true whether SW20 is in the + position or— position. The minimum level of +70 volts represents the point where V24B is taken into saturation by a sufficiently positive setting of R17 when SW20 is in the — position, or by a sufficiently negative setting of R17 when SW20 is in the + position. The maximum level of +130 volts represents the point where V24B is taken into cutoff by a sufficiently negative setting of R17 when SW20 is in the — position, or by a sufficiently positive setting of R17 when SW20 is in the + position. As will be seen later, the voltage at the plate of V24B must pass through the approximate center of the range (about +100 volts) in order to cause the Trigger Multivibrator to change states.

For small triggering signals, R17 is set such that the average dc level of the plate of V24B is close to the center of its range. Then a small triggering signal, as amplified by V24, is sufficient to carry the plate voltage through the +100-volt point. When a large triggering signal is applied and it is desired to trigger on an extreme postitive or negative point of it, R17 is set such that V24B is well into saturation, or cutoff, depending on whether triggering is desired on a negative or positive point on the signal and on a negative or positive slope. In this case, the triggering signal must be large enough to overcome the saturation or cutoff of V24B and produce an additional 30 volts of swing at the plate of V24B in order to cause the Trigger Multivibrator to change states.

It should be noted that the voltages given in the foregoing discussion are typical nominals only and will vary somewhat from instrument to instrument and with time.

Trigger Multivibrator

The Trigger Multivibrator, V45, is a typical two-state Schmitt circuit. When the voltage at its input grid (grid of V45A) is above a certain critical level (neglecting hysteresis for the moment), the Trigger Multivibrator is in one state, with V45A conducting and V45B cut off. When the Trigger Multivibrator is in this state, the voltage at its output (plate of V45B) is +250 volts. When the voltage at the input grid is below the critical level (still neglecting hysteresis), the Trigger Multivibrator is in the other state, with V45A cut off and V45B conducting. When the Trigger Multivibrator is in this second state, the voltage at its output is about +230 volts. The transition from one state to the other occurs very rapidly regardless of how slowly the voltage at the input grid passes the critical level. Thus the output of the Trigger Multivibrator is a 20-volt square wave. The negative-going portion of the square wave occurs when the voltage at the input passes the critical level while moving in a negative direction; the positive-going portion of the square wave occurs when the voltage at the input passes the critical level while moving in a positive direction. As mentioned before, only the negative-going portion of the square wave is of significance timewise. By means of the SLOPE switch and the LEVEL control, this point can be made to coincide with virtually any point on the incoming triggering signal.

Actually, the input voltage level at which the Trigger Multivibrator changes states on a negative-going signal is slightly lower than the input voltage level at which it changes states on a positive-going signal. The difference between the two input voltage levels at which the two changes in state occur is the hysteresis of the circuit. To maintain stable triggering, the incoming triggering signal must be large enough that, when it is amplified by the Trigger Input Amplifier, it will have sufficient amplitude to overcome the hysteresis of the Trigger Multivibrator.

It will be seen in the discussion of the Sweep Generator that not every negative trigger pulse from the Sweep Trigger initiates a sweep. During sweep time, the negative trigger pulses have no effect on the Sweep Generator. It is only after a sweep has been completed and all circuits have returned to their quiescent state that the Sweep Generator will be retriggered by the Sweep Trigger.

Automatic Triggering Mode

When the LEVEL control is turned fully counterclockwise, the AUTO. switch, SW17, is activated and converts the Trigger Multivibrator from a bistable configuration to an astable (free running) configuration. This is accomplished by coupling the grid circuit of V45B to the grid circuit of V45A via R40. The time constant thus formed is such that, in the absence of a triggering signal, the Trigger Multivibrator free-

runs at about 50 cps. However, since the triggering signals from the Trigger Input Amplifier are still coupled to the Trigger Multivibrator through C31, any triggering signal over 50 cps in frequency will produce synchronized operation of the Trigger Multivibrator at the triggering signal frequency. In the absence of any such triggering signal, the sweep continues to be triggered at a 50-cps rate. This provides a base line from which to make dc voltage measurements and also provides an indication that the instrument is adjusted to display any signal that might be applied to the INPUT connector.

SWEEP GENERATOR

The Sweep Generator, upon receipt of a negative trigger pulse from the Sweep Trigger, produces a linearly rising (sawtooth) voltage which is applied through the Horizontal Amplifier to the crt horizontal deflection plates. This causes the electron beam to move from left to right across the crt screen and form the sweep. The amplitude of the sawtooth voltage is about 100 volts. Its rate of rise is controlled by the values of the Timing Capacitor and Timing Resistor switched into the circuit by the SWEEP TIME/CM control on the front panel.

The Sweep Generator consists basically of three main circuits; the Sweep-Gating Multivibrator, the Miller Runup Circuit, and the Hold-Off Circuit. The Sweep-Gating Multivibrator consists of V135A, V135B, V145A and associated circuitry. The essential components of the Miller Runup Circuit are: The Miller Tube, V160A; the Runup Cathode Follower, V160B; the Disconnect Diodes, V152A and V152B; the Timing Capacitor, C160; and the Timing Resistor, R160. The Hold-Off Circuit consists of the Hold-Off Diode, V152C; the Hold-Off Cathode Follower, V145B; the Hold-Off Resistor, R181; and the Hold-Off Capacitance, C181 and C160 (the Hold-Off Circuit makes use of some of the same timing capacitors as the Miller Runup Circuit).

Sweep Generation

In the quiescent state—that is, when no sweep is being generated—V135A is conducting and V145A is cut off. The plate of V145A is about —2.5 volts with respect to ground. The Disconnect Diodes are conducting and hold both sides of the Timing Capacitor at about —2.5 volts. With its cathode grounded and its grid at —2.5 volts, V160A is conducting heavily and its plate is at about +30 volts.

A negative trigger pulse, arriving at the grid of V135A from the Sweep Trigger, causes the Sweep-Gating Multivibrator to switch rapidly to its other state. That is, V135A cuts off and V145A conducts. As V145A conducts, the increased current through the common cathode resistor, R144, raises the cathode voltage of the two tubes. This holds V135A in Cutoff after the negative trigger pulse has passed. Since V135A is now in cutoff, further trigger pulses arriving at its grid will have no effect on the circuit until after the sweep has been completed and the grid has been returned to its quiescent level by the Hold-Off Circuit. Thus the sweep is actually triggered at a submultiple of the triggering signal, provided the sweep time is significantly greater than the period of the triggering signal.

As V145A conducts, its plate voltage goes down, cutting off the Disconnect Diodes. When the Disconnect Diodes cut off, the plates of the Timing Capacitor are no longer held at —2.5 volts, and the Timing Capacitor starts to charge toward the instantaneous potential difference between the —100-volt supply and the potential on the cathode of V160B. However, as the lower plate of the Timing Capacitor starts to move in a negative direction, it takes the grid of V160A with it. This produces a positive swing at the plate of V160A which is coupled, through B167 and V160B, to the upper plate of the Timing Capacitor. This positive swing on the upper plate tends to prevent the lower plate from swinging negatively. It also increases the voltage to which the Timing Capacitor is trying to charge. The effect is to "straighten out" the charging curve by increasing the charging voltage with each increment of charge on the capacitor. Since the gain of V160A is about 200, the potential on the upper plate moves about 100 volts with respect to ground while the potential on the lower plate moves about one-half volt. The result is an extremely linear sawtooth at the cathode of V160B, which is applied through the Horizontal Amplifier to the horizontal deflection plates of the crt.

Sweep Length

The length of the sweep—that is, the distance the spot moves across the screen—is determined by the setting of the SWP. LENGTH adjustment, R176. As the sweep voltage rises at the cathode of V160B, there is proportionate rise in voltage at the wiper arm of the SWP. LENGTH adjustment. This increases the voltage at the plate, and therefore the cathode, of V152C and at the grid and cathode of V145B. As the voltage at the cathode of V145B rises, the voltage at the grid of V135A also rises. When the voltage at the grid of V135A rises to the point where V135A comes out of cutoff, the Sweep-Gating Multivibrator reverts rapidly to its original state, with V135A conducting and V145A cut off. The voltage at the plate of V145A rises, carrying with it the voltage at the plates of Disconnect Diodes.

V152B starts conducting, and forms a discharge path for the Timing Capacitor, through R147, the —100-volt power supply, and the cathode resistance of V160B. This brings the grid of V160A quickly back up to its quiescent level. The rise in voltage at the grid causes the tube to conduct more, so the plate voltage drops, carrying with it the grid and cathode of V160B.

When the voltage at the cathode of V160B returns to about —2.5 volts, V152A conducts, clamping the voltage at this point. The circuit has now returned to its quiescent level and is ready for the next trigger.

Hold Off

The Hold-Off Circuit prevents the Sweep Generator from being triggered until after the Miller Runup Circuit has stabilized in the quiescent condition following the previous sweep. It does this by holding the grid of V135A positive enough to keep V135A in conduction.

During sweep time, the rising voltage at the cathode of V152C charges up the Hold-Off Capacitance, C160 and C181. Then, at the end of the sweep, the voltage at the plate of V152C drops suddenly and the cathode tries to

follow it. The cathode however, is held up by the charge on the Hold-Off Capacitance which must discharge exponentially through the 4.7 M Hold-Off Resistor, R181. This, then, holds the grid and cathode of V145B and the grid of V135A high enough to hold V135A in conduction for a length of time determined by the time constant of the Hold-Off Capacitance and the Hold-Off Resistor. The amount of hold-off time required is determined, in general, by the sweep rate. For this reason, the SWEEP TIME/CM control changes the amount of capacitance in the Hold-Off Circuit simultaneously with that of the Timing Circuit.

Sweep Stability

The SWEEP STABILITY ADJUST, R111, regulates the quiescent dc level of the grid of V135A. This potentiometer (a front panel adjustment) is adjusted so that after the decay of the hold-off voltage the grid of V135A is just high enough (with the FREE RUN switch open) to hold V135A in conduction. In this case, a sweep can be produced only when a negative trigger pulse from the Sweep Trigger drives V135A into cutoff. Turning the LEVEL control fully clockwise closes the FREE RUN switch and shorts out R111. This places a more negative voltage on the grid of V135A such that V135A cuts off upon decay of the hold-off voltage and the next sweep is initiated immediately (no trigger pulse is necessary). The result is a free-running sweep whose period is the total of the sweep time plus the hold-off time at any given setting of the SWEEP TIME/CM control. (This is compared to a fixed repetition rate of about 50 cps when the LEVEL control is turned fully counterclockwise to the AUTO. position to make the Trigger Multivibrator in the Sweep Trigger free run.)

Unblanking

The positive rectangular pulse appearing at the cathode of V135B during sweep time is applied as an unblanking pulse to the crt. Action of this pulse is discussed under the description of the Crt Circuit later in this section. It should be noted that, when the SWEEP TIME/CM control is in the HORIZ. AMPLIFIER ONLY position, the Sweep-Gating Multivibrator is disabled, and there is no current flowing through V135A or V145A. Therefore, the cathode of V135B is held at a potential of about +205 volts and the crt is continously unblanked.

HORIZONTAL AMPLIFIER

The Horizontal Amplifier is a cathode-coupled paraphase amplifier which converts a single-ended input to a push-pull output and applies it to the horizontal deflection plates of the crt. When the SWEEP TIME/CM control is in any position but the HORIZ. AMPLIFIER ONLY position, the sawtooth waveform from the Sweep Generator is applied through a divider network to the grid of V374. When the SWEEP TIME/CM control is in the HORIZ. AMPLIFIER position, the grid of V374 is connected through the HORIZONTAL VARIABLE control, R310, to the EXT. HORIZ. connector on the front panel. This provides a means of applying an external signal to the horizontal deflection plates.

The Horizontal Amplifier has a nominal sensitivity of 0.5 volt per centimeter of deflection with the HORIZONTAL VARIABLE control set fully clockwise. The gain can be adjusted by means of the SWP. CAL. adjustment, R379.

Horizontal positioning is accomplished by varying the dc level of the grid of V384 by means of the HORIZONTAL POSITION control, R361. This varies the average dc level of the two plates of the amplifier inversely to one another.

CRT CIRCUIT

The crt in the Type RM504 Oscilloscope makes use of an extra set of deflection plates for unblanking during sweep time. One of these plates has fixed potential of about +225 volts on it; the other is tied to the cathode of V135B in the Sweep Generator. Quiescently, this latter plate is held at a relatively low potential, in the vicinity of +80 volts. Therefore, the electron beam in the crt is deflected forward and absorbed by the +225-volt plate; none of it reaches the screen. During sweep time, however, the unblanking pulse from V135B raises the potential of the second plate from +80 volts to about +205 volts which permits the beam to pass on through to the crt screen.

The INTENSITY control varies the control grid of the crt from about —20 volts to —150 volts with respect to the cathode. Connections are provided on the rear of the oscilloscope cabinet to couple an ac signal to the control grid to provide intensity modulation of the trace if desired.

CALIBRATOR

The Calibrator provides a 25-millivolt square wave and a 500-millivolt square wave for use in calibrating the gain of the Vertical Amplifier. The two amplitudes are obtained by tapping off at different points in a voltage divider network.

The square wave is produced by turning off and on of B886. This is accomplished by the combined action of B886, B883, and C883. B886 and B883 are neon tubes which nominally drop about 60 volts when they are conducting. However, if they are not conducting, they require about 80 volts across them to start conduction.

During the time that B886 is turned off, B883 is conducting. This causes C883 to discharge, which allows both plates of B883 to move in a positive direction (60 volts apart). When the common connection at the top of the two neon tubes reaches a potential of about +80 volts with respect to ground, B886 conducts. The current through R886 and R887 produces a 500-millivolt drop across them and the voltage at the upper end of B886 is, therefore, about +60.5 volts with respect to ground. Since the upper plate of C883 is now at about +20 volts with respect to ground, the potential across B883 is only about 40 volts, and B883 stops conducting. With no current through B883 to maintain or build up the charge on C883, the upper plate of C883 starts to move in a negative direction. The upper end of B883 is held steady at +60.5 volts by the drop across B886, R886, and R887, so when the potential on the upper plate of C883 becomes —20 volts with respect to ground, B883 conducts. This drops the voltage at the upper end of the two neon tubes to about +40 volts, and B886 cuts off, completing one cycle of the square wave.

It should be noted that the potentials mentioned in the foregoing discussion (except the drop across R886 and R887) are typical nominals only, and may vary considerably among different units. The only effect will be a slight variation in the frequency and symmetry of the output waveform.

The CAL. ADJ. adjustment, R880, provides a means of adjusting the voltage drops across R886 and R887 to exactly 500 millivolts by controlling the current through them.

POWER SUPPLY

T601 provides B+ voltage (about 500 volts) for the power supply oscillator tube, V620, and filament power for the graticule lights and all of the tubes, except the first stage of the Input Amplifier. The rest of the voltages used in the oscilloscope are provided by the secondary of T620.

V620, the primary of T620, and part of the secondary of T620 form an Armstrong oscillator circuit to drive T620 at about 25 kc. Each of the outputs of the secondary of T620 bears a fixed turns ratio to the others such that a change in one effects a proportional change in each of the others. Adjustment and regulation of all of the output voltages, then, is accomplished through adjustment and regulation of just one output, the —100-volt output.

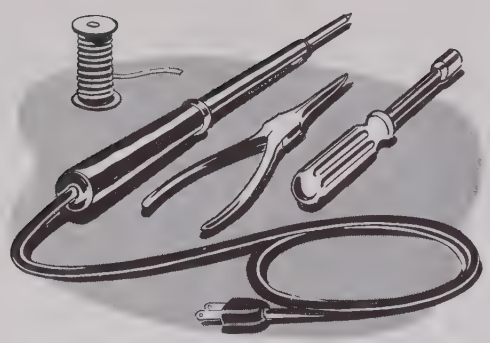
This, in turn, is referenced to the 85-volt drop across the voltage regulator tube, V659.

Adjustment of the output voltages is accomplished by means of the —100 ADJ., R641. Moving the wiper arm of this adjustment in a positive direction reduces the bias on V634B. This, in turn lowers the voltage at the plate of V634B and, therefore, at the grid of V634A. This causes an increase in voltage at the plate of V634A which in turn increases the screen voltage of V620. Increasing the screen voltage of V620 increases the Gm and therefore the gain, of the tube, and thereby increases the amplitude of oscillations in the secondary of T620. This results in a greater output from all of the supplies.

Regulation is accomplished in virtually the same manner. A lowering of the source voltage to which the oscilloscope is connected, or lowering of any of the output voltage due to loading, causes the volts per turn in the secondary of T620 to decrease. This causes the —100-volt supply to drop (move positively) with the resulting rise in the grid voltage of V634B. This results, as before, in a rise in the screen voltage of V620 and an increase in the amplitude of oscillations, bringing the power supply output back to their nominal values.

An increase in any of the output voltages, whatever the reason, has the opposite effect on the screen voltage of V620 and decreases the amplitude of oscillations in T620.

Regulation of the power supply outputs will be accomplished as long as the source voltage remains within the limits described in Section 2 of this manual.



SECTION 5

MAINTENANCE

Preliminary Instructions

PREVENTIVE MAINTENANCE

Visual Inspection

The oscilloscope should be visually inspected periodically for possible impending circuit defects. This would include such things as loose or broken connections, damaged binding posts, improperly seated tubes, scorched wires or resistors, missing tube shields, and broken terminal strips. For most visual troubles the remedy is apparent; however, particular care must be taken when heat-damaged components are detected. Overheating of parts is often the result of other, less apparent, defects in the circuit. It is essential to determine the cause of overheating before replacing heat-damaged parts, in order to prevent further damage.

Calibration

The Type RM504 Oscilloscope is a stable instrument which should provide many hours of trouble-free operation. However, to insure the reliability of measurements we suggest that you calibrate the instrument after each 500 hours of operation (or every six months, if used intermittently). A complete step-by-step procedure for calibrating the instrument is presented in Section 6 of this manual.

REMOVAL AND REPLACEMENT OF PARTS

General Information

Procedures required for replacement of most parts in the Type RM504 Oscilloscope are obvious. Detailed instructions for their removal are therefore not required. Other parts, however, can best be removed if a definite procedure is followed. Instructions for the removal of these parts are contained in the following paragraphs. Any time a tube or component is replaced in a circuit, that circuit and/or any others affected by its output should be recalibrated.

Replacement of Switches

Methods for removal of defective switches are, for the most part, obvious and only a normal amount of care is required. Single wafers are normally not replaced on the switches used in the Type RM504. If one wafer is defective, the entire switch should be replaced. Switches can be ordered from Tektronix, either wired or unwired, as desired.

Tube Replacement

Tubes should not be replaced unless they are actually causing trouble. Often during routine maintenance it will be necessary to remove tubes from their sockets. It is important that each tube be returned to its original socket unless it is actually defective. Unnecessary replacement or switching of tubes will often necsessitate recalibration of the instrument. If tubes require replacement, it is recommended that they be replaced by previously checked, high quality tubes.

Soldering Precautions

In the production of Tektronix instruments, a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond can be broken by repeated use of ordinary tin-lead solder, or by the application of too much heat. Occasional use of ordinary solder will not break the bond if too much heat is not applied.

It is advisable to have a stock of solder containing about 3% silver if you frequently perform work on Tektronix instruments. This type of solder is used frequently in printed circuitry and should be readily available. It may also be purchased directly from Tektronix in one-pound rolls (order by part number 251-514).

Because of the shape of the terminals on the ceramic terminal strips, it is advisable to use a wedge-shaped tip on your soldering iron when installing or removing parts from the strips. A wedge-shaped tip allows you to apply heat directly to the solder in the terminals and reduce the amount of heat required. It is important to use as little heat as possible.

Replacement of Ceramic Terminal Strips

To remove damaged ceramic terminal strips, first unsolder all connections. Then, if accessibility permits, cut off the protruding portion of the spacers and yokes on the opposite side of the chassis (see Fig. 5-1). Pull the entire assembly (strip, yokes, spacers) away from the chassis. If the assembly is difficult to remove or if the protruding portion of the spacers and yokes cannot be cut off, use a mallet and a punch to knock the yokes and spacers through from the other side.

When installing new ceramic strips, place the spacers in the chassis holes first, then insert the yoke pins through

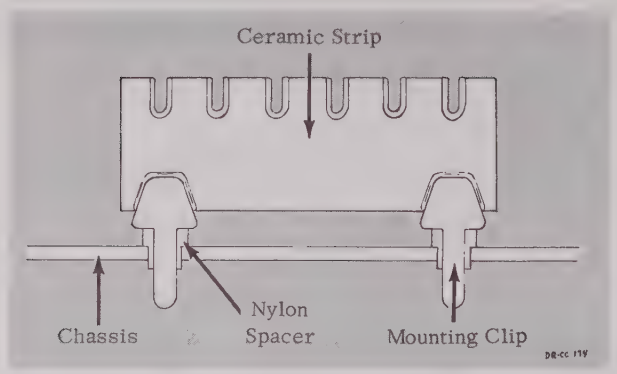


Fig. 5-1. Ceramic terminal strip mounted in chassis.

the spacers. Using a plastic or hard rubber mallet, tap the ceramic strip lightly above the yokes to seat the yokes firmly in the spacers. If desired, the extending portion of the yoke pins may be cut off to within about an eighth of an inch of the lower end of the spacers.

Be sure to observe the soldering precautions described earlier in this section when resoldering connections on the ceramic terminal strip.

REPLACEMENT PARTS

Standard Parts

Replacements for all parts used in the Type RM504 Oscilloscope can be purchased directly from Tektronix at current net prices. However, since most of the components are standard electronic parts, they can generally be obtained locally in less time than required to obtain them from the factory. Before ordering or purchasing parts, be sure to consult the parts list to determine the tolerances and ratings required. The parts list gives the values, tolerances, ratings and Tektronix part number for all components used in the instrument.

Special Parts

In addition to the standard electronic components mentioned in the previous paragraph, special parts are also used in the assembly of the Type RM504 Oscilloscope. These parts are manufactured or selected by Tektronix to satisfy particular requirements. Occasionally they are manufactured expecially for Tektronix by other companies in accordance with Tektronix specifications. These parts, and most mechanical and structural parts, should be ordered directly from Tektronix since they are normally difficult or impossible to obtain from other sources. All parts may be obtained from the local Tektronix Field Office or Representative.

Parts Ordering Information

Each part in the Type RM504 Oscilloscope has a 6-digit Tektronix part number. This number and a description of the part will be found in the parts list. When ordering parts, be sure to include the following information:

1. A description of the part.
2. The part number.
3. The instrument type and serial number (and Mod. number, if any).

For example, a certain resistor should be ordered as follows: R143, 25.6K, ½ watt, fixed resistor, tolerance 1%, part number 309-136 for a Type RM504 Oscilloscope, serial number _____. When parts are ordered in this manner, we are able to fill your orders promptly, and delays that might result from transposed numbers in the part number are avoided.

NOTE

Always include the instrument Type and SERIAL NUMBER (and MOD. number) in any correspondence concerning this instrument.

Since the production of your instrument, some of the parts may have been superseded by new or improved components. In such cases, the part numbers of these new components will not be listed in the Parts List. However, if you order a part from Tektronix and it has been superseded by a new component, the new part will be shipped in place of the part ordered. Your local Tektronix Field Engineering Office has knowledge of these changes and may call if a change in your purchase order is necessary.

Replacement information sometimes accompanies the new components to aid in their installation.

Troubleshooting Information

The troubleshooting information presented here is divided into two parts, Circuit Isolation and Circuit Troubleshooting. It is intended, in general, that upon encountering a trouble in the oscilloscope you will refer to the Circuit Isolation information first. This will help you to isolate the trouble to one of the major circuits of the oscilloscope. Then you will refer to the troubleshooting instructions for that particular circuit in the Circuit Troubleshooting information following. This will help you to isolate the trouble to one of the stages within the circuit. General troubleshooting instructions are presented as appropriate at the beginning of the two parts.

CIRCUIT ISOLATION

This part of the Troubleshooting Information lists most of the trouble symptoms which may be encountered in the Type RM504 Oscilloscope and describes procedures for isolating the troubles to particular circuits. In most cases, simple front panel operations and observations can be made to determine which circuit is defective; in other cases, internal checks or measurements are required.

Whenever an apparent trouble is isolated to a particular stage, you should first try to adjust the calibration of the

circuit, if possible, according to the procedures described in Section 6 of this manual. Many apparent troubles are merely the result of improper calibration.

Inadequate or incorrect Power Supply voltages can sometimes cause troubles which seem to bear no relationship to the Power Supply, but seem instead to due to a malfunction of some other circuit. For this reason, it is usually a good idea to check the Power Supply output voltages first when it has been definitely established that a trouble does exist in the oscilloscope. If you find that one or more of the Power Supply voltages are not correct, you should refer to the paragraph on Troubleshooting the Power Supply in the last part of this section.

Remember, any time a component or tube is replaced in a circuit, that circuit and the other circuits affected by its output must be recalibrated.

No Trace

If no trace appears on the screen when the oscilloscope is properly set up for triggered operation, turn the LEVEL control to FREE RUN, both POSITION controls to midrange, the SENSITIVITY control to 20 VOLTS/CM, the AC-DC-GND switch to GND, and the INTENSITY control fully clockwise.

CAUTION

Be ready to turn the INTENSITY control down quickly when a trace or spot does appear to prevent possible damage to the crt screen.

If a trace now appears, try to adjust the sweep stability according to the procedure given in Section 6 of this manual. If it is not possible to adjust the sweep stability as described in the procedure, the trouble is in the Sweep Trigger. If a trace does not appear when the controls are set as described above, set the SWEEP TIME/CM control to HORIZ. AMPLIFIER ONLY. If a spot now appears, the trouble is in the Sweep Generator. If no spot appears, short the crt vertical deflection plates together at the crt neck pins. If a spot now appears, the trouble is a dc unbalance in the Vertical Amplifier. If no spot appears, remove the shorting strap and short the crt horizontal deflection plates together at the crt neck pins. If a spot now appears, the trouble is a dc unbalance in the Horizontal Amplifier. If a spot does not appear, remove the shorting strap and check the voltage at pin 3 of V135. If this is about +205 volts, the trouble is in the Crt Circuit. If the voltage at pin 3 is significantly lower than +205, the trouble is in the Sweep Generator.

Short Trace

If the trace is shorter than normal, and cannot be set at the proper length with the SWP. LENGTH adjustments, set the SWEEP TIME/CM control to HORIZ. AMPLIFIER ONLY and the HORIZONTAL VARIABLE control fully clockwise. Apply the 500-millivolt Calibrator signal directly to the EXT. HORIZ. connector. If one centimeter of horizontal deflection is obtained, the trouble is in the Sweep Generator or in the divider (R191, R192, R193) at the sweep input to the Horizontal Amplifier. If one centimeter of horizontal deflection is not obtained, the trouble is in the Horizontal Amplifier.

Unstable Triggering

If unstable triggering can be obtained but stable triggering cannot (waveform is displayed, but will not remain stationary), check the triggering control settings first. If all the triggering controls are set properly and the triggering is still not stable, adjust the sweep stability according to the procedure given in Section 6 of this manual. If this does not cure the trouble, or if it is not possible to adjust the sweep stability according to the procedure, the trouble is in the Sweep Trigger. If the trace free-runs with no triggering signal applied and cannot be turned off with the LEVEL control, then the trouble is in the Sweep Generator.

Insufficient Vertical Deflection

If there is insufficient vertical deflection on the crt screen, or no vertical deflection at all, the trouble is in the Vertical Amplifier. If the vertical deflection is correct at the middle of the crt screen, but decreases as the trace is moved up or down, the trouble may also be in the CRT Circuit. However, you should check the Output Amplifier in the Vertical Amplifier before investigating the Crt Circuit.

Waveform Distortion

A certain amount of waveform distortion is normal, especially on fast-changing waveforms. However, an abnormal amount of waveform distortion indicates a trouble in the Vertical Amplifier.

Improper Crt Geometry and Spurious Crt Spots

If waveforms are consistently bowed near the sides and top and bottom of the crt screen, the trouble is in the CRT Circuit, probably within the crt itself. The same is true if there are spurious spots or halos on the face of the crt which cannot be completely extinguished with the INTENSITY control.

Improper Sweep Timing

If the sweep timing is incorrect in some, but not all, positions of the SWEEP TIME/CM control, one or more of the timing resistors or capacitors in the sweep timing circuit have changed in value. By comparing the control positions in which the timing is incorrect with the Timing Switch circuit diagram, you will be able to determine which component or components are probably faulty.

If the sweep timing is incorrect in all positions of the SWEEP TIME/CM control, try to adjust the sweep timing according to the procedure described in Section 6. If this does not cure the trouble, set the SWEEP TIME/CM control to HORIZ. AMPLIFIER ONLY, the HORIZONTAL VARIABLE control fully clockwise, and apply the 500-millivolt output of the Calibrator directly to the EXT. HORIZ. connector. A one-centimeter-long horizontal trace should appear on the screen. Position this trace across the screen with the HORIZONTAL POSITION control. If the trace remains one centimeter long no matter where it is placed horizontally on the screen, the trouble is in the Sweep Generator. If the trace is not one centimeter long or if it varies in length as it is moved from

one side of the screen to the other, the trouble is in the Horizontal Amplifier. If the trace is one centimeter long when it is placed in the center of the screen but decreases in length as it is moved toward either side, the trouble may be in the Crt Circuit. However, you should check the Horizontal Amplifier before investigating the CRT Circuit.

CIRCUIT TROUBLESHOOTING

This portion of the section contains troubleshooting procedures for locating a defective stage within a given circuit to which a trouble has been isolated. Once the defective stage is identified, a visual check of the components of that stage should be performed, even if such was performed on the entire circuit earlier. Normally, if a visual check fails to reveal the cause of the malfunction, the next step should be to check the tube or tubes of the stage. This should be done only by substitution, never by tube checker. A tube checker cannot satisfactorily indicate how well a given tube will perform in a given circuit. If there is more than one tube in the stage, the best method of checking them is to change all of them. Then, if this cures the trouble, substitute the original tubes back into the stage to determine the faulty one. This will save time and trouble if more than one tube in a stage is bad. Always replace tubes found to be good to their original sockets; this can eliminate the need for unnecessary recalibration.

If replacement of the tube or tubes in a stage does not cure the trouble, check the remainder of the circuit by voltage and resistance checks. Typical voltages to be encountered at many points throughout the oscilloscope are given on the circuit diagrams in the Parts List and Schematic Diagrams. It should be noted that these voltages are typical nominals only and may vary somewhat from instrument to instrument.

If a test oscilloscope is available, troubleshooting may be performed by signal tracing through the various circuits of the Type RM504. Typical waveforms to be encountered at various points throughout the instrument are also given on the circuit diagrams.

TROUBLESHOOTING THE POWER SUPPLY

Proper operation of every circuit in the Type RM504 Oscilloscope depends upon proper operation of the Power Supply. The output voltages must remain within their specified tolerances for the instrument to maintain its calibration.

NO OUTPUT VOLTAGE. If there is no output voltage from any of the power supply circuits and the graticule lamps and tube filaments are not glowing, the trouble is in the primary circuit of the line transformer T601. Check for a blown fuse, for proper operation of the POWER switch, and for open primary windings.

If there is no output voltage from any of the power supply circuits but the graticule lamps do light, then the trouble is in the high-voltage secondary of T601 or in the high voltage oscillator (V620). Measure the voltage at the junction of D612 and C612 (see Fig. 6-3). If the voltage here is less than about 400 volts, the trouble lies in the secondary winding of T601 or in the voltage doubler circuit made up of C611, C612, D611, and D612. If the voltage is about 550 volts or more, the trouble lies in the oscillator. Before replacing V620, check R621, C620, C621 and the secondary of T620; if any of these components are faulty they could cause V620 to burn out.

If the proper output voltage is obtained from at least one of the power supply circuits, the oscillator is operating properly and need not be checked. In this case, you should check the rectifier and other components associated with the inoperative supply or supplies.

FAILURE TO REGULATE AT THE CORRECT VOLTAGE. If the supplies fail to regulate at the proper voltages, first check to see that the line voltage to which the oscilloscope is connected is within the specified limits (see Section 2 of this manual). If the line voltage is correct and the outputs of the Power Supply are off by only a small amount, it may be possible to bring them within tolerances by adjusting the —100 ADJ. adjustment. It should be noted, however, that whenever the setting of the —100 ADJ. adjustment is changed, the entire instrument must be recalibrated.

If the supplies cannot be brought into proper regulation with the —100 ADJ. adjustment, check all the Power Supply tubes by substitution. If this does not cure the trouble, check the voltage at the junction of C612 and D612 (see Fig. 6-3). It should be about +500 volts. Also check the resistances and capacitances in the regulator circuit.

If there is excessive ripple on any of the supplies but not on others, check for open or leaky capacitors in the faulty circuit.

TROUBLESHOOTING THE VERTICAL AMPLIFIER

NO TRACE. If a spot or trace appears on the screen when the vertical deflection plates are shorted together but disappears when the short is removed (with the VERTICAL POSITION control set at midrange), the Vertical Amplifier is in a state of dc unbalance. First, try to adjust the Vertical Amplifier dc balance according to the procedure described in Section 6. If this does not cure the trouble, set the SENSITIVITY control to the .2 VOLTS/CM position. Then, with the insulated shorting strap, short between the pairs of points shown in Fig. 5-2, starting at the right and progressing toward the left. As you short between the points in turn, the spot should appear on the screen as the connections are made. You may have to adjust the VERTICAL POSITION control when shorting between the grids and plates of V434. When you reach a point where the spot cannot be positioned on the screen when the connections are made, the stage immediately following this point is at fault.

INSUFFICIENT VERTICAL DEFLECTION. If the change in vertical deflection is small, try to recalibrate the Vertical Amplifier sensitivity according to the procedure described in Section 6 of this manual. If the Vertical Amplifier sensitivity cannot be properly calibrated, check the tubes by substitution. If this does not cure the trouble, check the components which can affect the gain of the amplifier but not the dc balance. Such parts are common cathode resistors and common emitter resistors. The gain of the Output Amplifier should be about 40.

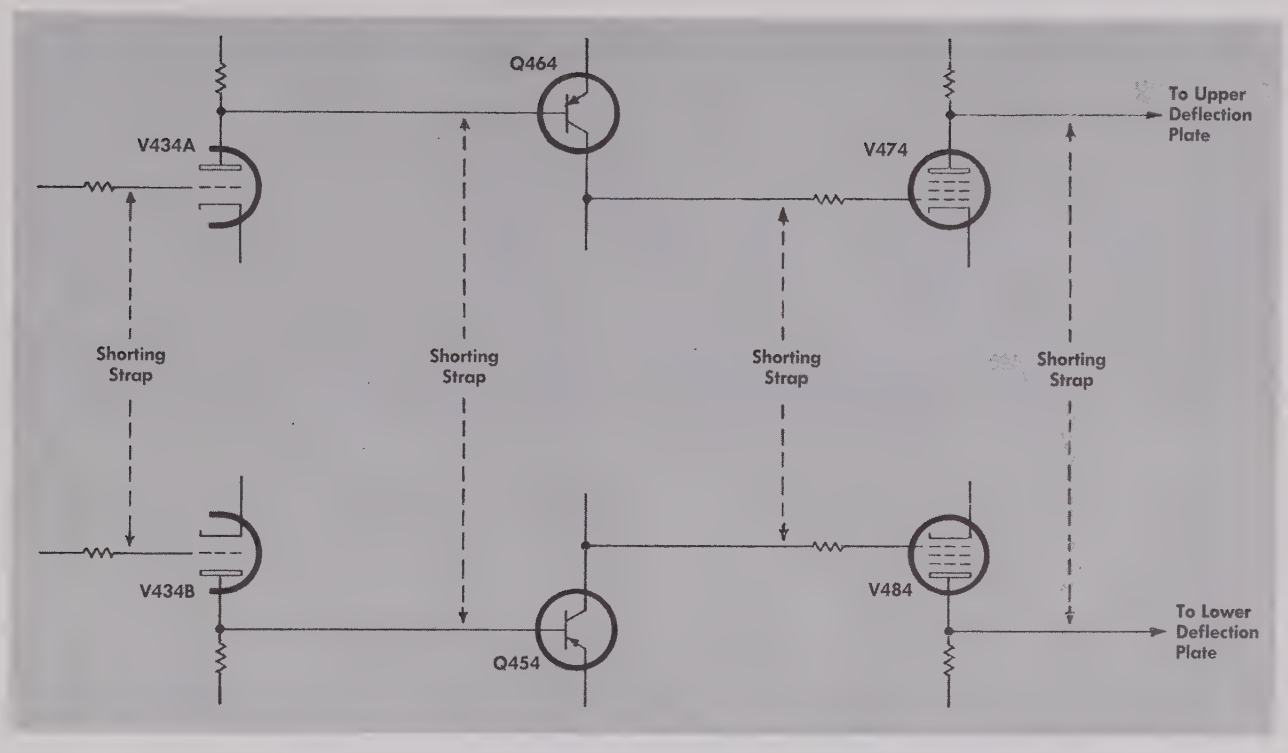


Fig. 5-2. Checkpoints for isolating Vertical Amplifier dc unbalance.

WAVEFORM DISTORTION. Waveform distortion can be divided into two categories—low frequency and high-frequency. If a square wave is displayed on the crt screen, the type of distortion can be determined by the shape of the displayed waveform. High frequency distortion will primarily affect only the leading and trailing edges of the waveform while low-frequency distortion will primarily affect the mid-portion of the waveform.

Waveform showing low-frequency distortion and two types of high-frequency distortion are shown in Fig. 5-3. The shape of these waveforms will vary widely, however, with the cause of distortion and the frequency of the applied square wave. A nominal amount of low-frequency distortion is normal for very low input frequencies when ac coupling is used, and a nominal amount of high-frequency distortion is normal at the upper frequency limits of the instrument. It is only when this distortion becomes excessive in the normal frequency range of the instrument that it constitutes a trouble.

Low frequency distortion is usually caused by a change in the time constant of the input coupling circuit. This, in turn, is usually caused by a tube becoming gassy and drawing grid current. So when low-frequency distortion is encountered check the three tubes in the Vertical Amplifier by substitution.

In all cases of high-frequency distortion, you should first check the compensation of the probe you are using, if any, and then check the Vertical Amplifier high-frequency compensation according to the procedure described in Section 6. If this does not cure the trouble, then check the tubes of the Vertical Amplifier by substitution.

TROUBLESHOOTING HORIZONTAL AMPLIFIER

NO TRACE. If a no-trace condition has been isolated to the Horizontal Amplifier, set the SWEEP TIME/CM control in the HORIZ. AMPLIFIER ONLY position and short the grids of the two Horizontal Amplifier tubes together. If the spot now appears, the trouble lies in the grid circuit of one of the tubes. If the spot does not appear, check the tubes by substitution. If the spot still does not appear, the trouble is in the plate, screen, or cathode circuit of one of the tubes.

SHORT TRACE. If a short trace is caused by a trouble in the Horizontal Amplifier, the sweep timing will also be affected, and you should proceed as directed in the following paragraph.

IMPROPER SWEEP TIMING. If improper sweep timing has been isolated to the Horizontal Amplifier, check the tubes by substitution. If this does not cure the trouble, check the other components in the circuit by voltage and resistance measurements.

TROUBLESHOOTING THE SWEEP TRIGGER

If the Sweep Trigger is found to be at fault, first check the triggering in all positions of the SOURCE, COUPLING, and SLOPE switches to determine if the trouble is in the switching. The 500-millivolt output of the Calibrator can be used for both the internal and external triggering signal. (When checking the internal triggering, set the SENSITIVITY control to .5 VOLTS/CM.) Do not use the AUTO, or FREE RUN positions of the LEVEL control during this step.

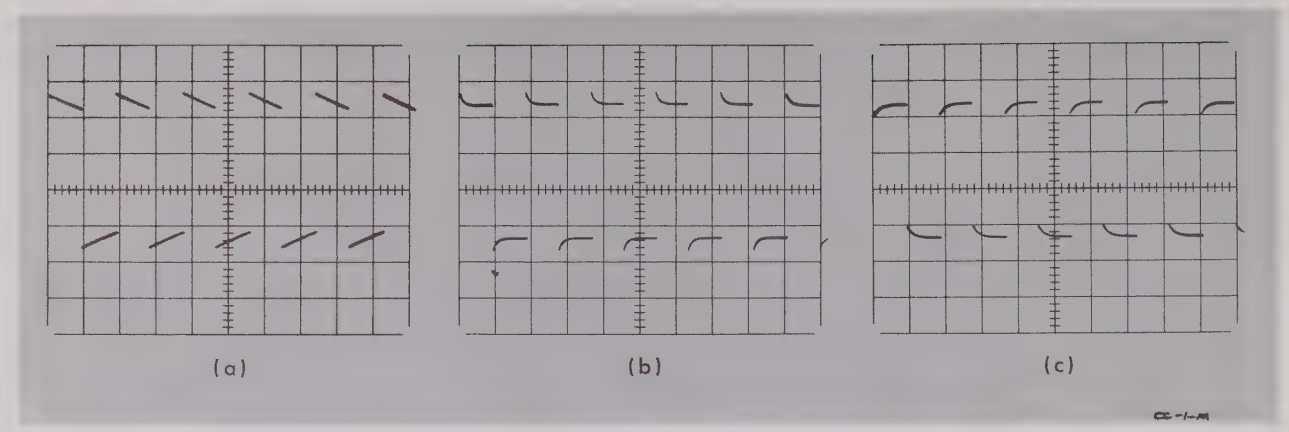


Fig. 5-3. Frequency distortion. (a) Low-frequency distortion of an ac-coupled 100-cps square wave due to attenuation of the low-frequency components of the waveform. (b) High-frequency distortion of a 1000-cps square wave due to excessive boost of the high-frequency components of the waveform. (c) High-frequency distortion of a 1000-cps square wave due to attenuation of the high-frequency components of the waveform.

If triggering is absent in all positions of the SOURCE, COUPLING, and SLOPE switches, set the LEVEL control to AUTO. If a sweep now appears, the trouble is in the Trigger Input Amplifier. If a sweep does not appear, try to adjust the sweep stability according to the procedure described in Section 6. If it is not possible to adjust the sweep stability as described in the procedure, then the Trigger Multivibrator is at fault.

TROUBLESHOOTING THE SWEEP GENERATOR CIRCUIT

NO HORIZONTAL SWEEP. If the Sweep Generator is not producing a sawtooth waveform when the TRIGGER LEVEL control is in the FREE RUN position, some defect in the circuit is causing the output to remain at some fixed voltage. A clue to the cause of this trouble can be obtained by measuring the plate voltage of the Miller tube, V160A, pin 6.

NOTE

All voltages in this section should be measured with a 20,000 ohms-per-volt voltmeter or a vacuum-tube voltmeter.

The voltage reading obtained at the plate of V160A will probably be approximately +200 volts, or approximately +30 volts. A reading of +200 volts indicates that the Miller Runup Circuit has run up and has not been reset, while a reading of +30 volts indicates that the Miller Runup Circuit is not being allowed to run up. The condition that exists will depend on the type of trouble occurring in the circuit. The two conditions of plate voltage will be handled separately in the following paragraphs.

High Voltage at the plate of the Miller tube, V160A, indicates that the tube is cut off. This can result from any one of the following conditions: (1) the Disconnect Diodes do not conduct, (2) the Sweep-Gating Multivibrator does not reset, (3) the Hold-Off Circuit does not reset the Sweep-Gating Multivibrator, or (4) the Runup C.F. does not drive the Hold-Off Circuit. The defective stage can be detected by a series of systematic voltage measurements. When an improper voltage reading is obtained, this will indicate the defective stage.

Check the voltage at the grid (pin 2) of the Miller tube, V160A. The static voltage at the Miller grid is determined by conduction through the Timing Resistor, R160, (from —100-volt bus), the lower diode, V152B, and resistor R147. If the voltage reading is less than —4 volts, V152B is probably conducting normally and can be eliminated as a possible cause of the trouble. If the voltage is more negative than approximately —20 volts, the diode is probably not conducting in the proper manner. In this case, check V152 and resistor R147.

Measure the voltage at the output of the Sweep Generator circuit (pin 8 of V160B). If this voltage is approximately +150 volts, the Runup Cathode Follower stage may be assumed to be operating correctly. If this voltage is low, however, the stage is defective and its grid and cathode circuits should be checked.

Next, measure the voltage at the cathode of V145B, pin 3. If this voltage is more positive than —55 volts, the trouble is in the Sweep-Gating Multivibrator. Check the tubes and resistors in this circuit. The voltage divider network in the cathode of V135B is particularly critical.

If the voltage at the cathode of V145B, pin 3, is more negative than —55 volts, check the tubes in the Hold-Off Circuit, the Hold-Off Capacitor, and resistors in the cathode circuit of the two tubes.

Low Voltage at the plate of the Miller tube indicates that the tube is conducting quite heavily and is not being allowed to perform its normal runup operation. If this trouble exists on only a few ranges of the SWEEP TIME/CM control, the trouble is probably an open timing resistor. If the trouble exists on all ranges of the SWEEP TIME/CM control, monitor the voltage at pin 3 of V145B and adjust the STABILITY ADJUST control for the most negative voltage (approximately —65 volts or lower). With this voltage, the sweep should free run, producing a trace on the screen. If the sweep does not free run, the trouble is in the Sweep-Gating Multivibrator.

If the voltage at pin 3 of V145B remains relatively constant as the STABILITY ADJUST control is rotated, a defect in the Hold-Off Circuit is indicated.

SHORT TRACE. If the short trace on the screen has been attributed to trouble in the Sweep Generator, check the values of R174, R176, and R178.

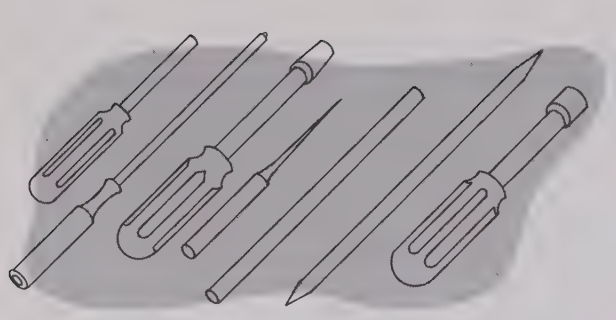
UNSTABLE TRIGGERING. If a free-running trace, with no triggering signal applied, cannot be turned off by moving the LEVEL control out of the FREE RUN position, the trouble is in the Sweep-Gating Multivibrator of the Sweep Generator. check V135 and V145 by substitution. If this does not cure the trouble, check the resistances in the grid and cathode circuits of V135A and V145A.

IMPROPER SWEEP TIMING. Improper sweep timing can be caused by the sawtooth waveform in the Sweep Generator building up too slowly or building up nonlinearly. If this improper sweep timing occurs at only a few settings of the SWEEP TIME/CM control, the trouble is in one of the components of the Timing Switch. If it occurs at all settings of the SWEEP TIME/CM control, the trouble is in the Miller Runup Circuit or the Runup Cathode Follower.

TROUBLESHOOTING THE CRT CIRCUIT

Troubles in the Crt circuit are usually caused by defects in the voltage dividers, in the heater circuit, or in the crt itself. The voltage dividers and heater circuit can be checked by voltage and resistance measurements. If all the circuits appear to be satisfactory, replace the crt according to the procedure described in the first part of this section.

NOTES



SECTION 6

CALIBRATION

Introduction

We recommend that the Type RM504 Oscilloscope be calibrated after each 500 hours of operation or every 6 months, whichever comes first. It should not require more frequent calibration. However, it may be necessary to check the calibration of certain parts of the instrument whenever tubes or other circuit components are replaced (see Section 5, Maintenance).

Apparent trouble in the instrument may be due to improper calibration of one or more circuits. Consequently, this section of the manual should be used in conjunction with the Maintenance section during troubleshooting work. If trouble occurs, you must be sure that it is not due to improper calibration before proceeding with more detailed troubleshooting.

In the instructions that follow, the steps are arranged in the proper sequence for a complete calibration of the instrument. However, the steps may be performed out of order or individually, without regard to the other steps, as long as each step is performed completely, including references to the performance or verification of other adjustments. Fig. 6-1 shows the location of internal adjustments referred to in this procedure.

EQUIPMENT REQUIRED

The following equipment is necessary for complete calibration of the Type RM504 Oscilloscope:

1. D.C. voltmeter (sensitivity of at least 5000 Ω/v), calibrated for an accuracy of 1% or better at 12.6, 85, 100, and 250 volts, and for an accuracy of 3% or better at 3000 volts.

2. Accurate rms-reading ac voltmeter, having a range of at least 0-125 volts. (0-250 volts for 234-volt operation.)

3. Variable autotransformer having a rating of at least 150 watts.

4. Time-Mark Generator, Tektronix Type 180 or Type 180A or equivalent. Time-Mark Generator used must have markers at 1 μsec, 10 μsec, 100 μsec, 1 msec, 5 msec, 10 msec, and 100 msec with an accuracy of least 1%.

5. Square-Wave Generator, Tektronix Type 105 or equivalent. Required specifications are: (1) output frequency of approximately 1 kilocycle, (2) risetime of 0.02 μsec or less, and (3) output amplitude variable from about 40 millivolts to 100 volts.

6. Test Oscilloscope with calibrated vertical deflection factors from .01 to 10 volts per division.

7. Low-capacitance calibration tool: Tektronix part number 003-000 or equivalent.

8. Coaxial cable suitable for applying the outputs of the square-wave generator and the time-mark generator to the input of the Type RM504.

9. 47-μμf Input Capacitance Standardizer, Tektronix Type CS47 or equivalent.

CALIBRATION PROCEDURE

Initial Setup

Remove the Type RM504 from its rack and remove top and bottom covers. Set the front-panel controls as follows (controls not listed may be left in any position).

SLOPE	+
COUPLING	AC
SOURCE	INT.
LEVEL	Ccw but not AUTO.
SWEEP TIME/CM	1mSEC
SWEEP TIME/CM VARIABLE	CALIBRATED
INTENSITY	Fully ccw
SENSITIVITY	.1 VOLTS/CM
SENSITIVITY VARIABLE	CALIBRATED
POSITION controls	Midrange
AC-DC-GND	DC

NOTE

The controls should be placed in these positions during each of the following steps except when otherwise specified.

Connect the autotransformer to a suitable power source and the Type RM504 Oscilloscope to the autotransformer. Set the output of the autotransformer to the nominal voltage for which your instrument is wired (see Section 2). Turn power switch to ON. Allow the equipment to warm up for at least 5 minutes before proceeding with the following adjustments.

Power Supply Output Voltage Regulation

With the dc voltmeter, measure the output voltage of the —100-, +85-, +100-, +250-, and —3000-volt supplies at the points indicated in Fig. 6-2. Set the —100 ADJ. adjustment so that the —100-volt supply is within ±2% and the other supplies are within ±5% of their rated values.

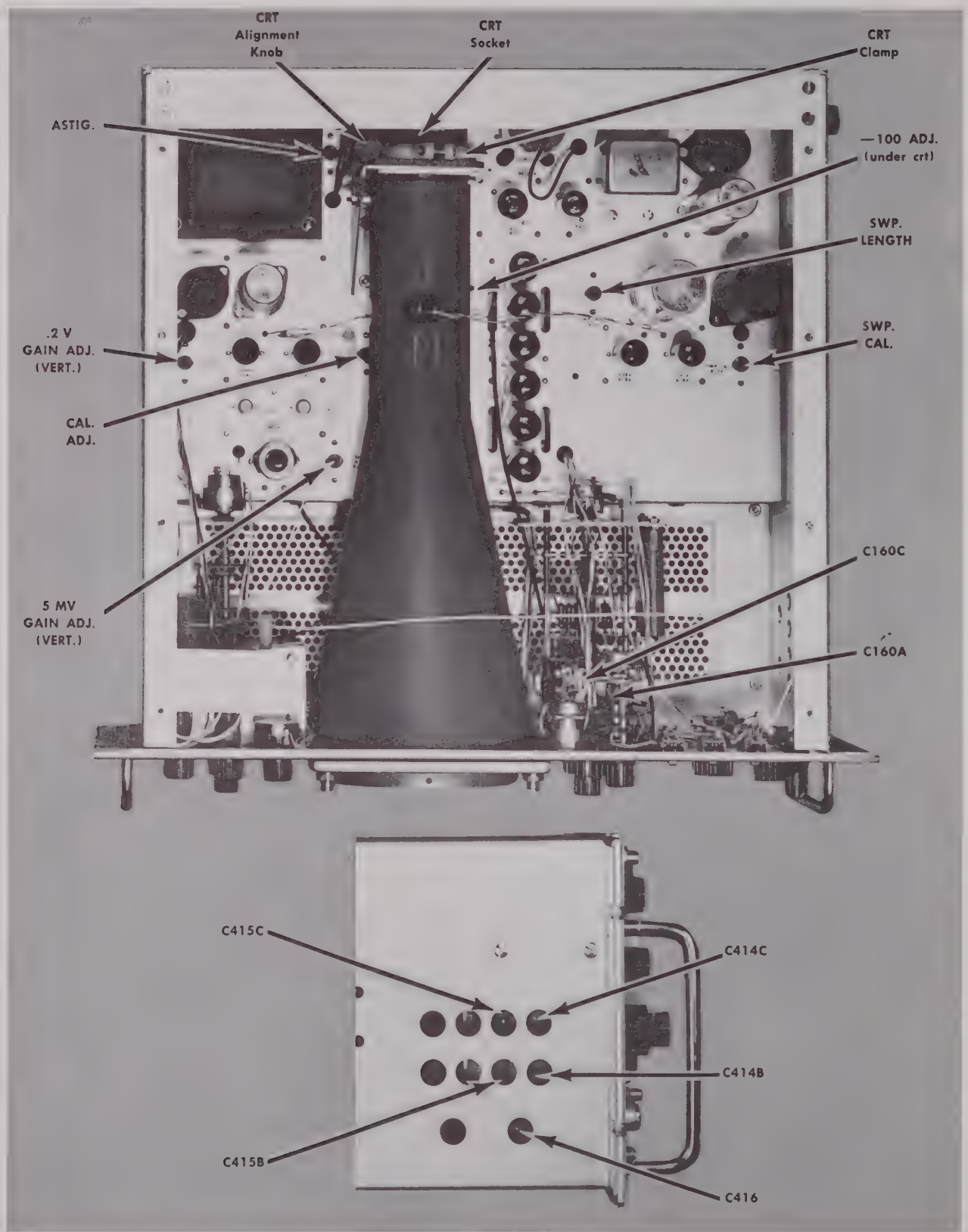


Fig. 6-1. Top and side views of the Type RM504.

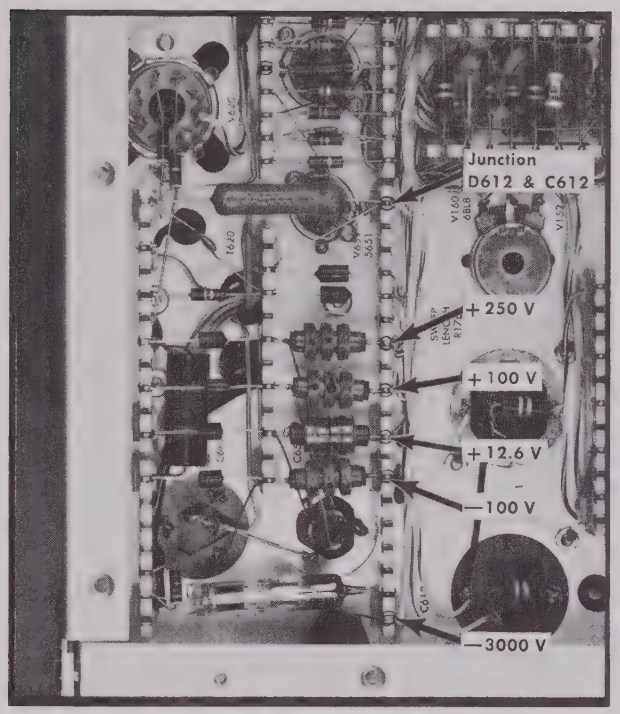


Fig. 6-2. Location of the Power Supply test points.

NOTE

Do not adjust the —100 ADJ. adjustment unless one or more of the supplies is actually out of tolerance. If the setting of this adjustment is changed, the entire instrument should be recalibrated.

Vary the autotransformer output voltage between the line voltage limits specified in Section 2. All of the regulated voltages should remain within the tolerances stated above over this range.

Power Supply Output Voltage Ripple

Using the test oscilloscope, check the amplitude of the 120-cycle ripple voltage at the output of each supply except the —3000-volt supply, with the autotransformer output set at the nominal voltage for the instrument. Ripple at each output should be 25 millivolts or less. Do not attempt to measure the ripple on the —3000-volt supply. 20 mV of 30-kc ripple on the +250-volt supply is permissible, and any 30-kc ripple on the +85-volt supply can be disregarded.

Calibrator Output

Connect the input probe of the test oscilloscope to the CAL. OUT 500 mV terminal on the front panel. Adjust the CAL. ADJ. adjustment (R880) for an output of 500 millivolts of amplitude. Disconnect the test oscilloscope.

Crt Alignment

Check to see that the face of the crt rests snugly against the graticule. If it does not, loosen the crt clamp, and move the crt forward by pushing on the tube socket. Then tighten the crt clamp.

Set the LEVEL control to the FREE-RUN position, and turn up the INTENSITY control until a trace is visible (it may be necessary to adjust the VERTICAL POSITION control). Adjust the FOCUS control for the narrowest trace. With the VERTICAL POSITION control, position the trace directly behind the center horizontal graticule line. If the trace is tipped relative to the line, rotate the crt alignment knob until the trace and the graticule line are parallel.

Crt Astigmatism

Set the FOCUS control fully clockwise, and the SWEEP TIME/CM control to the HORIZ. AMPLIFIER ONLY position. Position the spot onto the screen, and adjust the ASTIG. ADJ. (R864) so that the defocused spot is as nearly circular as possible. The INTENSITY control may have to be adjusted to produce the defocused circle, but should be turned down when a sharply focused spot is produced so as not to burn the crt face. Adjust the FOCUS control so that the spot is in sharp focus.

Sweep Stability

Set the LEVEL control to the FREE RUN position and center the trace vertically on the screen. Adjust the INTENSITY and FOCUS controls to obtain a bright, well-defined trace. Set the LEVEL control to AUTO. and the STABILITY ADJUST adjustment (R111, front panel screwdriver adjustment) fully counterclockwise. Next, turn the STABILITY ADJUST control clockwise until a trace appears on the crt. Note the position of the screwdriver adjustment. Advance the adjustment farther clockwise until the trace brightens. Finally, set the adjustment approximately midway between the position where the trace first appears and the position where it brightens.

Vertical Amplifier DC Balance

Set the LEVEL control to the FREE RUN position. Set the SENSITIVITY control to .2 VOLTS/CM and the SENSITIVITY VARIABLE control to the CALIBRATED position. Turn the INTENSITY control up to display a trace, and center the trace vertically on the screen with the VERTICAL POSITION control. Set the AC-DC-GND switch to GND. Adjust the DC BAL. adjustment (front panel screwdriver adjustment) so that the trace does not shift vertically as the SENSITIVITY control is rotated back and forth between the .2 VOLTS/CM position and the 5 mV/CM position.

Vertical Amplifier Sensitivity

Set the LEVEL control to the AUTO. position and the SENSITIVITY control to .1 VOLTS/CM. Connect a jumper wire from the CAL. OUT 500 mV connector to the INPUT connector. Adjust the FOCUS, INTENSITY, and POSITION controls for a suitable display. Adjust the .2 V GAIN ADJ. adjustment (R478) for a vertical deflection of five centimeters on the crt screen.

Remove the jumper wire from the CAL. OUT 500 mV connector and connect it from the CAL. OUT 25 mV con-

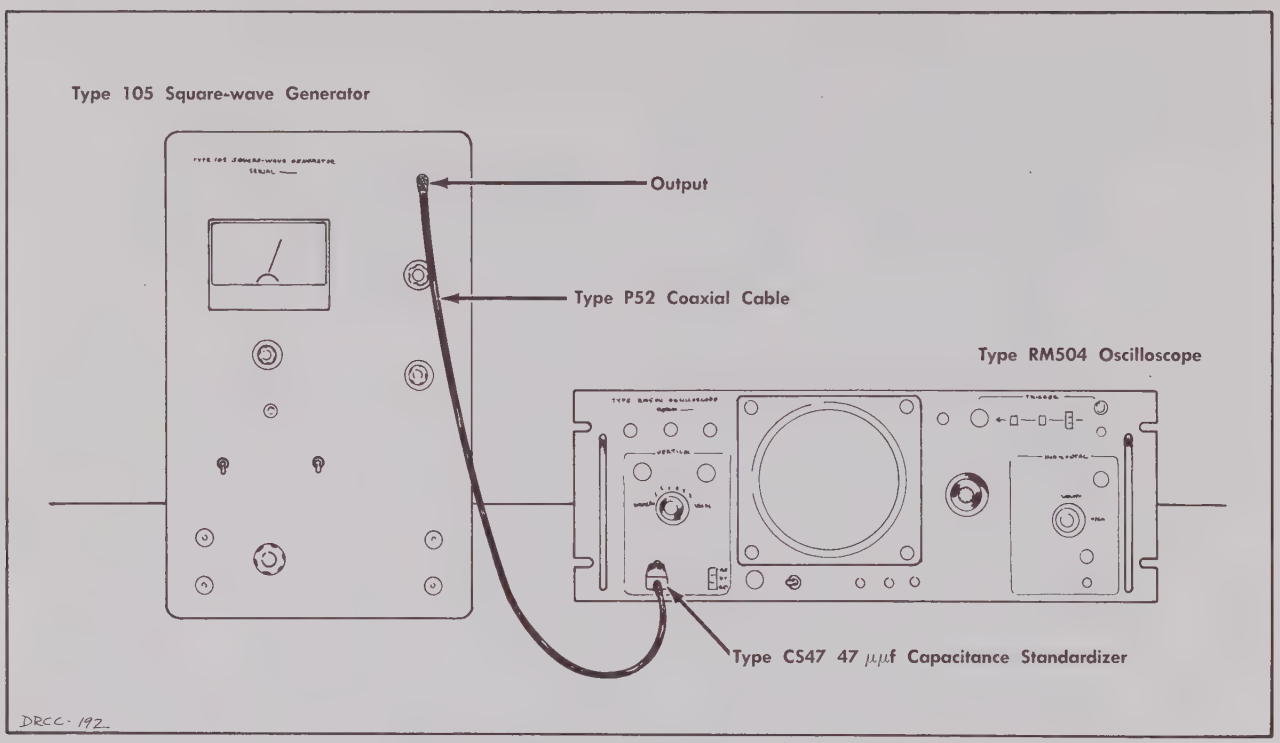


Fig. 6-3. Tektronix Type 105 Square-wave Generator connected for high-frequency compensation of the Type RM504 Vertical Amplifier.

nector to the INPUT connector. Set the SENSITIVITY control to 5 mV/CM. Adjust the 5mV GAIN ADJ. adjustment (R460) for five centimeters of vertical deflection on the crt screen.

Repeat this entire step until both adjustments are correct without further adjustment. Disconnect the jumper wire.

Vertical Amplifier High Frequency Compensation

Set the SWEEP TIME/CM control to .5 mSEC, the SENSITIVITY control to .2 VOLTS/CM, the AC-DC-GND switch to AC, and the LEVEL control to AUTO. Connect the output of the square-wave generator through the 47-$\mu\mu$f capacitance standardizer to the INPUT connector of the Type RM504 Oscilloscope. Adjust the square-wave generator for an output frequency of 1 kc. Set the FOCUS and INTENSITY controls for the best display. Fig. 6-3 shows the Tektronix Type 105 Square-Wave Generator connected to the Type RM504 Oscilloscope for this step.

Set the SENSITIVITY control to the positions indicated in Table 6-1 and adjust the corresponding capacitors for the best square-wave response. C416, C415B, and C414B affect the overall level of the square wave; C415C and C414C have the most effect on a small portion of the leading edge and corner.

Maintain about four centimeters of vertical deflection by adjusting the output amplitude of the square-wave generator as you switch the SENSITIVITY control from one setting to the next.

Disconnect the square-wave generator from the Type RM504 Oscilloscope when you have completed this step.

TABLE 6-1

SENSITIVITY setting	Adjust
.2 VOLTS/CM	C416
.5 VOLTS/CM	C415B, C415C
5 VOLTS/CM	C414B, C414C

Horizontal Amplifier Gain

Set the LEVEL control to AUTO. and the AC-DC-GND switch to AC. Apply 1 millisecond markers from the time-mark generator to the INPUT connector of the Type RM504 Oscilloscope. Set the FOCUS, INTENSITY, and POSITION controls for the best display. Adjust the SWP. CAL. adjustment (R379) for a display of one marker per centimeter on the crt screen. (Use the HORIZONTAL POSITION control to align the markers with the graticule lines.)

Sweep Length

Set the LEVEL control to FREE RUN and adjust the INTENSITY control to display a trace. Adjust the SWP. LENGTH adjustment (R176) for a sweep length of approximately 10.5 centimeters.

Sweep Timing

Some unavoidable distortion or nonlinearity may exist within one centimeter of the right- and left-hand edges of the graticule. For this reason, all sweep-timing measure-

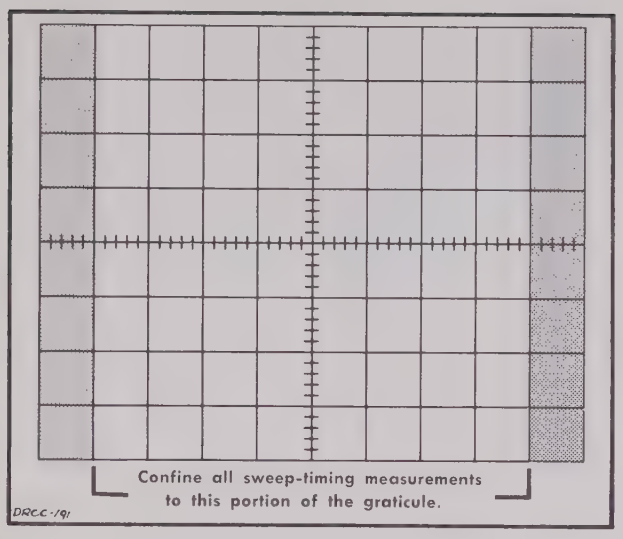


Fig. 6-4. Sweep-timing measurement limits.

ments should be made between the 1-centimeter and 9-centimeter points on the 10-centimeter-wide graticule (see Fig. 6-4).

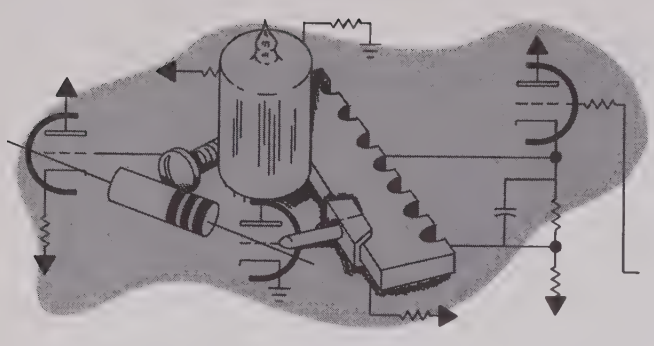
Set the SWEEP TIME/CM control to the positions shown in the first column of Table 6-2, apply time markers as noted in the second column, and note that the time markers are observed on the crt screen as noted in the third column. When checking the .1 SEC. sweep rate, it may be necessary to adjust the LEVEL control for a stable display.

Next, apply 1-microsecond markers from the time-mark generator to the INPUT connector. Set the SWEEP TIME/CM control to the 1μSEC position. Adjust the LEVEL, SENSITIVITY, and POSITION controls to obtain a stable display. Adjust C160A for one marker per centimeter on the crt screen. This adjusts the sweep timing of the 1, 2, and 5 μSEC settings of the SWEEP TIME/CM control.

TABLE 6-2

SWEEP TIME/CM Setting	Time Markers Applied	Observe
.1 mSEC	100-μsec	1 marker/cm
1 mSEC	1-msec	1 marker/cm
2 mSEC	1-msec	2 marker/cm
5 mSEC	5-msec	1 marker/cm
10 mSEC	10-msec	1 marker/cm
.1 SEC	.1-sec	1 marker/cm

NOTES



SECTION 7

PARTS LIST AND SCHEMATICS

ABBREVIATIONS

Cer.	Ceramic	n	Nano or 10^{-9}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, metal cased	p	Pico or 10^{-12}
f	Farad	PTB	Paper, "Bathtub"
G	Giga, or 10^{9}	PMC	Paper, metal cased
GMV	Guaranteed minmum value	Poly.	Polystyrene
h	Henry	Prec.	Precision
K or k	Kilohms or kilo (10^{3})	PT	Paper Tubular
M/Cer.	Mica or Ceramic	T	Terra or 10^{12}
M or meg	Megohms or mega (10^{6})	v	Working volts DC
μ	Micro. or 10^{-6}	Var.	Variable
$\mu\mu$	Micromicro or 10^{-12}	w	Watt
m	milli or 10^{-3}	WW	Wire-wound

HOW TO ORDER PARTS

Replacement parts are available from or through your local Tektronix Field Office.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Field Office will contact you concerning any change in part number.

PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
		Bulbs	
B167	150-002	Neon, Type NE-2	
B601	150-001	Incandescent, Type #47 Graticule Light	
B602	150-001	Incandescent, Type #47 Graticule Light	
B603	150-018	Incandescent, G. E. #12 Pilot Light	
B883	Use *150-009	Neon, Type NE-2 Aged & Checked	
B886	Use *150-009	Neon, Type NE-2 Aged & Checked	
		Capacitors	

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors are as follows: (with exceptions)

3 V - 50 V = −10%, +250%
51 V -350 V = −10%, +100%
351 V-450 V = −10%, +50%

C10	283-001	.005 μf	Discap	500 v		
C15	283-000	.001 μf	Discap	500 v		
C20	283-000	.001 μf	Discap	500 v		
C31	283-002	.01 μf	Discap	500 v		
C37	281-510	22 μμf	Cer.	500 v		
C43	281-518	47 μμf	Cer.	500 v		
C131	281-511	22 μμf	Cer.	500 v	10%	
C141	281-501	4.7 μμf	Cer.	500 v	±1 μμf	
C160A	281-007	3-12 μμf	Cer. Var.			
C160B	Use 281-574	82 μμf	Cer.	500 v	10%	
C160C	281-010	4.5-25 μμf	Cer. Var.			
C160D	*291-008	.001 μf	Mylar		±½%	
C160E	*291-029	.01 μf	Mylar Timing Series		±½%	
C160F		.1 μf				
C160G		1 μf				
C167	283-000	.001 μf	Discap	500 v		
C181	281-509	15 μμf	Cer.	500 v	10%	
C361	283-001	.005 μμf	Discap	500 v		
C379	281-525	470 μμf	Cer.	500 v		
C408A	281-503	8 μμf	Cer.	500 v	±.5 μμf	X452-up
C408C	281-542	18 μμf	Cer.	500 v	10%	X452-up
C410	285-579	.022 μf	MT	600 v	5%	
C414B	281-012	7-45 μμf	Cer. Var.			
C414C	281-005	1.5-7 μμf	Cer. Var.			
C414E	281-560	198 μμf	Cer.	500 v	10%	
C415B	281-012	7-45 μμf	Cer. Var.			
C415C	281-005	1.5-7 μμf	Cer. Var.			

Capacitors *(continued)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
C416	281-010	4.5-25 μμf	Cer.	Var.		
C421	283-003	.01 μf	Discap	150 v		
C434	281-504	10 μμf	Cer.	500 v	10%	101-451X
C440	283-001	.005 μf	Discap	500 v		
C450	281-518	47 μμf	Cer.	500 v		
C453	283-012	.1 μf	Discap	100 v		
C456	281-500	2.2 μμf	Cer.	500 v		101-439
C456	281-538	1 μμf	Cer.	500 v		440-451
C456	281-500	2.2 μμf	Cer.	500 v		452-up
C457	281-542	18 μμf	Cer.	500 v	10%	101-439
C457	281-508	12 μμf	Cer.	500 v	±.6 μμf	440-up
C460	281-518	47 μμf	Cer.	500 v		
C466	281-500	2.2 μμf	Cer.	500 v		101-439
C466	281-538	1 μμf	Cer.	500 v		440-up
C467	281-542	18 μμf	Cer.	500 v		101-439
C467	281-508	12 μμf	Cer.	500 v	±.6 μμf	440-up
C479	281-543	270 μμf	Cer.	500 v	10%	X440-up
C611	Use 290-0016-00	125 μf	EMC	350 v		
C612	Use 290-0016-00	125 μf	EMC	350 v		
C614	283-022	.02 μf	Discap	1400 v		X330-up
C620	Use 283-575	.01 μf	Mica	600 v	5%	
C621	283-001	.005 μf	Discap	500 v		
C624	290-106	10 μf	EMC	15 v		X330-up
C628	283-000	.001 μf	Discap	500 v		
C630	283-000	.001 μf	Discap	500 v		
C642	283-001	.005 μf	Discap	500 v		
C646	283-002	.01 μf	Discap	500 v		
C652A	Use 290-0126-00	10 μf	EMC	350 v		
C652B		50 μf	EMC	150 v		
C652C		100 μf	EMC	50 v		
C654A	Use 290-0126-00	10 μf	EMC	350 v		
C654B		50 μf	EMC	150 v		
C654C		100 μf	EMC	50 v		
C682	Use 290-0075-00	2 x 10 μf	EMC	250 v		
C684	Use 290-0023-00	2 x 40 μf	EMC	150 v		
C692A,B	283-034 (2)	.005 μf	Discap	4000 v		
C851A,B	283-034 (2)	.005 μf	Discap	4000 v		
C854	283-033	.001 μf	Discap	6000 v		
C858	283-001	.005 μf	Discap	500 v		
C883	285-543	.0022 μf	MT	400 v		
C886	283-028	.0022 μf	Discap	50 v		X450-up

Diodes

D44	152-008	Germanium T12G		
D152	152-0246-00	Silicon, Low leakage	0.25 W, 40 v	X2071-up
D452	152-008	Germanium T12G		X330-up
D462	152-008	Germanium T12G		X330-up
D611	152-048	Silicon IN2864 (or equiv.), 600 PIV, 500 MA		
D612	152-048	Silicon IN2864 (or equiv.), 600 PIV, 500 MA		
D652	*153-008	Silicon, Selected 600 PIV, 500 MA		
D662	*153-007	Silicon, Selected 400 PIV, 500 MA		
D672	*153-007	Silicon, Selected 400 PIV, 500 MA		
D682	*153-007	Silicon, Selected 400 PIV, 500 MA		

Fuses

Ckt. No.	Tektronix Part No.	Description	S/N Range
F601	159-041	1.25 Amp 3 AG Slo-Blo 117 v oper. 50 & 60 cycle	
	159-040	.7 Amp 3 AG Slo-Blo 234 v oper. 50 & 60 cycle	

Inductors

L419	108-204	3.9 mh	
L473	108-204	3.9 mh	101-451
L473	108-224	3.9 mh	452-up
L483	108-204	3.9 mh	101-451
L483	108-224	3.9 mh	452-up
L654	108-207	1 mh	
L664	108-207	1 mh	
L672	108-205	1 mh	
L684	108-207	1 mh	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R14	302-105	1 meg	½ w				
R15	302-474	470 k	½ w				
R17	311-184	1 meg		Var.		TRIG. LEVEL	
R19	302-225	2.2 meg	½ w				101-2289
R19	301-0225-00	2.2 meg	½ w			5%	2290-up
R20	302-274	270 k	½ w				101-2289
R20	301-0274-00	270 k	½ w			5%	2290-up
R22	302-471	470 Ω	½ w				
R23	302-471	470 Ω	½ w				
R25	302-273	27 k	½ w				
R26	Use 309-091	120 k	½ w		Prec.	1%	
R28	Use 310-070	33 k	1 w		Prec.	1%	
R34	302-681	680 Ω	½ w				
R35	302-272	2.7 k	½ w				
R36	302-471	470 Ω	½ w				X260-up
R37	309-055	370 k	½ w		Prec.	1%	
R38	309-003	500 k	½ w		Prec.	1%	
R40	302-275	2.7 meg	½ w				
R43	302-472	4.7 k	½ w				
R44	302-103	10 k	½ w				
R46	304-223	22 k	1 w				
R111	311-112	15 k		Var.		SWP/STABILITY ADJUST	
R112	301-273	27 k	½ w			5%	
R113	301-513	51 k	½ w			5%	
R134	309-043	82 k	½ w		Prec.	1%	
R135	301-184	180 k	½ w			5%	
R137	302-101	100 Ω	½ w				
R141	309-045	100 k	½ w		Prec.	1%	
R143	309-136	25.6 k	½ w		Prec.	1%	
R144	309-153	20 k	½ w		Prec.	1%	
R146	302-101	100 Ω	½ w				
R147	302-152	1.5 k	½ w				
R152	316-0226-00	22 meg	¼ w				X2300-up

Resistors *(continued)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R160A	309-014	1 meg	½ w		Prec.	1%	
R160B	309-023	2 meg	½ w		Prec.	1%	
R160C	309-087	5 meg	½ w		Prec.	1%	
R160X	302-823	82 k	½ w				
R160Y	311-182	200 k		Var.		SWP. TIME/CM	
R164	304-154	150 k	1 w				
R167	302-105	1 meg	½ w				
R168	302-104	100 k	½ w				
R171	302-101	100 Ω	½ w				
R174	304-273	27 k	1 w				
R176	Use 311-368	5 k	½ w	Var.		SWP. LENGTH	
R178	302-822	8.2 k	½ w				
R181	302-475	4.7 meg	½ w				
R191	309-195	90 k	½ w		Prec.	1%	
R192	309-159	5 k	½ w		Prec.	1%	
R193	302-184	180 k	½ w				
R310	311-026	100 k		Var.		HORIZ. ATTEN.	
R361	311-206	250 k		Var.		POSITION	
R364	302-224	220 k	½ w				
R365	302-822	8.2 k	½ w				
R371	302-471	470 Ω	½ w				
R373	310-065	56.5 k	1 w		Prec.	1%	
R376	309-176	43.4 k	½ w		Prec.	1%	
R378	302-122	1.2 k	½ w				101-229
	309-284	1.11 k	½ w		Prec.	1%	230-up
R379	Use 311-368	5 k		Var.		SWP. CAL.	101-229
	Use 311-363	2k	½ w	Var.			230-up
R383	310-065	56.5 k	1 w		Prec.	1%	
R386	309-176	43.4 k	½ k		Prec.	1%	
R408A	309-100	10 k	½ w		Prec.	1%	
R408C	309-283	3.33 k	½ w		Prec.	1%	
R408E	309-284	1.11 k	½ w		Prec.	1%	
R408G	309-285	526 Ω	½ w		Prec.	1%	
R408J	309-286	256 Ω	½ w		Prec.	1%	
R414C	309-145	990 k	½ w		Prec.	1%	
R414E	318-009	10.1 k	⅛ w		Prec.	1%	
R415C	309-142	900 k	½ w		Prec.	1%	
R415E	318-006	111 k	⅛ w		Prec.	1%	
R416	309-014	1 meg	½ w		Prec.	1%	
R419	Use 323-0323-00	22.6 k	½ w		Prec.	1%	
R421	311-184	1 meg		Var.		DC BAL	
R425	302-105	1 meg	½ w				
R426	302-222	2.2 k	½ w				101-2379
R426	302-0332-00	3.3 kΩ	½ w				2380-up
R434	309-090	50 k	½ w		Prec.	1%	
R438	310-074	38.3 k	1 w		Prec.	1%	

Resistors *(continued)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R440	302-104	100 k	½ w				
R441	302-471	470 Ω	½ w				
R444	309-090	50 k	½ w		Prec.	1%	
R448	310-074	38.3 k	1 w		Prec.	1%	
R450	302-102	1 k	½ w				
R451	303-333	33 k	1 w			5%	X440-up
R452	303-822	8.2 k	1 w			5%	
R453	301-103	10 k	½ w			5%	101-329
R453	301-682	6.8 k	½ w			5%	330-439
R453	301-103	10 k	½ w			5%	440-2379
R453	301-0133-00	13 k	½ w			5%	2380-up
R454	301-332	3.3 k	½ w				
R456	316-394	390 k	¼ w			5%	X330-439X
R457	309-228	12.5 k	½ w		Prec.	1%	
R458	302-105	1 meg	½ w				
R460	Use 311-364	20 k	½ w	Var.		5 MV GAIN ADJ.	
R461	301-911	910 Ω	½ w			5%	X440-up
R466	316-394	390 k	¼ w				
R467	309-228	12.5 k	½ w		Prec.	1%	
R468	302-105	1 meg	½ w				
R470	311-190	2 x 20 k		Var.		POSITION	
R471	302-101	100 Ω	½ w				
R473	308-105	30 k	8 w		WW	5%	
R476	308-108	15 k	5 w		WW	5%	
R477	306-123	12 k	2 w				
R478	Use 311-363	2 k		Var.		.2 V GAIN ADJ.	101-229
	Use 311-372	750 Ω	½ w	Var.			230-up
R479	309-102	402 Ω	½ w		Prec.	1%	X230-up
R481	302-101	100 Ω	½ w				
R483	308-105	30 k	8 w		WW	5%	
R486	308-108	15 k	5 w		WW	5%	
R487	306-123	12 k	2 w				
R488	311-189	2 k		Var.		VOLTS/CM	
R490	302-474	470 k	½ w				
R491	302-473	47 k	½ w				
R492	302-334	330 k	½ w				
R601	311-055	50 Ω		Var.		SCALE ILLUM.	101-419
R601	311-262	50 Ω		Var.	WW		420-up
R603	302-101	100 Ω	½ w				X330-up
R604	302-101	100 Ω	½ w				X330-up
R611	304-154	150 k	1 w				
R612	304-154	150 k	1 w				
R621	302-104	100 k	½ w				
R623	302-472	4.7 k	½ w				
R624	302-220	22 Ω	½ w				X330-up
R626	308-168	40 k	8 w		WW	5%	
R628	302-471	470 Ω	½ w				
R630	302-684	680 k	½ w				
R631	302-225	2.2 meg	½ w				
R632	302-101	100 Ω	½ w				

©

Resistors *(continued)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R634	302-333	33 k	½ w				
R635	302-563	56 k	½ w				
R637	302-474	470 k	½ w				
R640	309-234	154 k	½ w		Prec.	1%	101-1889
R640	323-0391-00	115 k	½ w		Prec.	1%	1890-up
R641	Use 311-403	20 k	½ w	Var.		—100 Adj.	
R642	309-151	174 k	½ w		Prec.	1%	101-1889
R642	323-0396-00	130 k	½ w		Prec.	1%	1890-up
R644	302-474	470 k	½ w				
R646	302-153	15 k	½ w				
R659	302-104	100 k	½ w				101-1889
R659	303-0513-00	51 k	1 w			5%	1890-up
R692	307-056	4.3 k	½ w			5%	
R840	304-824	820 k	1 w				
R841	304-824	820 k	1 w				
R842	304-824	820 k	1 w				
R844	311-041	1 meg		Var.		FOCUS	101-419
R844	311-261	1 meg		Var.			420-up
R845	302-474	470 k	½ w				
R847	311-188	500 k		Var.		INTENSITY	101-329
R847	311-242	200 k		Var.			330-419
R847	311-264	200 k		Var.			420-up
R849	302-473	47 k	½ w				
R851	302-155	1.5 meg	½ w				
R852	302-225	2.2 meg	½ w				101-329
R852	302-155	1.5 meg	½ w				330-up
R854	302-104	100 k	½ w				
R857	Use 302-393	39 k	½ w				
R858	302-104	100 k	½ w				
R860	302-224	220 k	½ w				
R862	302-104	100 k	½ w				
R864	Use 311-366	500 k	½ w	Var.		ASTIGMATISM	
R880	Use 311-366	500 k	½ w	Var.		CAL. ADJ.	
R881	309-019	1.75 meg	½ w		Prec.	1%	
R883	302-225	2.2 meg	½ w				
R886	309-316	4.75 k	½ w		Prec.	1%	
R887	309-178	250 Ω	½ w		Prec.	1%	

Switches

	Unwired	Wired			S/N Range
SW5	260-251		Slide	SOURCE	101-1759
SW5	260-0450-00		Slide	SOURCE	1760-up
SW10	260-145		Slide	COUPLING	101-1759
SW10	260-0449-00		Slide	COUPLING	1760-up
SW17	260-235	*262-351	Rotary	TRIG. LEVEL	
SW20	260-212		Slide	SLOPE	101-1759
SW20	260-0447-00		Slide	SLOPE	1760-up
SW160	260-327	*262-353	Rotary	TIME/CM	
SW410	260-316		Slide	AC/DC INPUT	101-1759
SW410	260-0448-00		Slide	AC/DC INPUT	1760-up
SW414	260-328	*262-352	Rotary	SENSITIVITY	101-451
SW414	260-328	*262-504	Rotary	SENSITIVITY	452-up
SW601	260-134		Toggle	POWER OFF	
TK601	260-336		Thermal Cutout 150°		

®

Transformers

Ckt. No.	Tektronix Part No.	Description	S/N Range
T601	Use *050-039	L.V. Power	101-269
	*120-203	L.V. Power	270-up
T620	Use *120-199	H.V. Power	

Transistors

Q454	Use 151-0045-00	2N1637
Q464	Use 151-0045-00	2N1637

Electron Tubes

V24	154-187	6DJ8
V45	154-187	6DJ8
V135	154-187	6DJ8
V145	154-187	6DJ8
V152	Use 154-453	6BJ7
V160	154-278	6BL8 or ECF80
V374	154-030	6CB6
V384	154-030	6CB6
V434	154-187	6DJ8
V474	154-030	6CB6
V484	154-030	6CB6
V620	154-277	6DQ6A
V634	154-278	6BL8 or ECF80
V659	154-052	5651
V692	154-051	5642
V859	*154-265	T5030-2 CRT Standard Phosphor

SECTION 8
MECHANICAL PARTS LIST

A list of abbreviations and special symbols in use throughout this manual will be found immediately preceding the Electrical Parts List, Section 7. Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Parts ordering information is also located immediately preceding Section 7.

EXPLODED VIEW

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	200-0382-00			1	COVER, graticule (See Ref. #3)
	- - - - - -			-	cover includes:
2	354-0116-00			1	RING, ornamental
	- - - - - -			-	mounting hardware: (not included w/cover)
3	210-0424-00			4	NUT, graticule
	210-0816-00			4	WASHER, rubber
4	331-0056-00			1	GRATICULE, 5 inches
5	337-0187-00			1	SHIELD, graticule light
6	260-0316-00	101	1759	1	SWITCH, slide — AC-DC-GND
	260-0448-00	1760		1	SWITCH, slide—AC-DC-GND
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
7	352-0007-00	101	419	1	HOLDER, fuse
	352-0014-00	420		1	HOLDER, fuse
8	129-0053-00			1	POST, binding
	- - - - - -			-	post includes:
	355-0507-00			1	STEM, adapter
	200-0103-00			1	CAP
	- - - - - -			-	mounting hardware: (not included w/post)
	210-0223-00			1	LUG, solder, 1/4 inch
	210-0455-00			1	NUT, hex., 1/4-28 x 3/8 inch
9	355-0043-00			4	STUD, graticule (replacement)
	- - - - - -			-	each stud includes:
	212-0507-00			1	SCREW, 10-32 x 3/8 inch, BHS
	210-0010-00			1	LOCKWASHER, internal, #10
10	200-0237-00	101	1129X	1	COVER, insulation, fuse holder
11	131-0081-00			1	CONNECTOR, 1 contact, female, UHF
12	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot)
	210-0494-00			1	NUT, hex., 3/8-32 x 1/2 x 11/16 inch
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	358-0010-00			1	BUSHING, 3/8-32 x 9/16 inch
13	- - - - - -			3	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
14	- - - - - -			3	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0207-00			1	LUG, solder, 3/8 inch

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
15	366-0033-00	101	419	1	KNOB, small black — SCALE ILLUM
	366-0134-00	420	1759	1	KNOB, small black — SCALE ILLUM
	366-0148-00	1760		1	KNOB, small charcoal—SCALE ILLUM.
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
16	366-0033-00	101	419	1	KNOB, small black — INTENSITY
	366-0134-00	420	1759	1	KNOB, small black — INTENSITY
	366-0148-00	1760		1	KNOB, small charcoal—INTENSITY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
17	366-0033-00	101	419	1	KNOB, small black — FOCUS
	366-0134-00	420	1759	1	KNOB, small black — FOCUS
	366-0148-00	1760		1	KNOB, small charcoal—FOCUS
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
18	333-0609-00			1	PANEL, front
19	367-0008-00			2	HANDLE, drawer
	- - - - - -			-	mounting hardware for each: (not included w/handle)
	212-0559-00			2	SCREW, 10-32 x 5/8 inch, FHS
20	366-0044-00	101	1759	2	KNOB, small black — POSITION
	366-0113-00	1760		2	KNOB, small charcoal—POSITION
	- - - - - -			-	each knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
21	366-0031-00			1	KNOB, small red — VARIABLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
22	366-0040-00	101	1759	1	KNOB, large black — VERTICAL SENSITIVITY
	366-0160-00	1760		1	KNOB, large charcoal—VERTICAL SENSITIVITY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
23	262-0352-00	101	451	1	SWITCH, wired — VERTICAL SENSITIVITY (See Ref. #29 & #30)
	262-0504-00	452		1	SWITCH, wired — VERTICAL SENSITIVITY (See Ref. #29 & #30)
	- - - - - -			-	switch includes:
	260-0328-00			1	SWITCH, unwired — VERTICAL SENSITIVITY
24	384-0209-00			1	ROD, extension
	376-0014-00			1	COUPLING, pot
25	406-0589-00			1	BRACKET, capacitor mounting
26	- - - - - -			10	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor alone)
	213-0034-00	101	268	2	SCREW, thread cutting, 4-40 x 5/16 inch, RHS
	214-0153-00	269		1	FASTENER, snap, double pronged
27	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot alone)
	210-0413-00			2	NUT, hex., 3/8-32 x 1/2 inch
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
28	406-0599-00			1	BRACKET, switch, attenuator, left
	- - - - - -			-	mounting hardware: (not included w/bracket alone)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
29	- - - - - -			-	mounting hardware: (not included w/switch)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, BHS
30	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch

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EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
31	260-0134-00			1	SWITCH, toggle — POWER ON
	- - - - - -			-	switch includes:
	210-0414-00			1	NUT, hex., $^{15}/_{32}$-32 x $^{9}/_{16}$ inch
	- - - - - -			-	mounting hardware: (not included w/switch)
	354-0055-00			1	RING, locking, switch
	210-0902-00			1	WASHER, .470 ID x $^{21}/_{32}$ inch OD
	210-0473-00			1	NUT, switch, $^{15}/_{32}$-32 x $^{5}/_{64}$ inch, 12 sided
32	366-0044-00	101	1759	1	KNOB, small black — TRIGGER LEVEL
	366-0113-00	1760		1	KNOB, small charcoal—TRIGGER LEVEL
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS
33	262-0351-00			1	SWITCH, wired — TRIGGER LEVEL (See Ref. #37)
	- - - - - -			-	switch includes:
	260-0235-00			1	SWITCH, unwired — TRIGGER LEVEL
34	179-0472-00			1	CABLE HARNESS, trigger switch
35	376-0014-00			1	COUPLING, pot
36	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot alone)
	210-0413-00			2	NUT, hex., $^{3}/_{8}$-32 x $^{1}/_{2}$ inch
37	210-0012-00			1	LOCKWASHER, internal, $^{3}/_{8}$ x $^{1}/_{2}$ inch
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, $^{3}/_{8}$ x $^{1}/_{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $^{9}/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^{3}/_{8}$-32 x $^{1}/_{2}$ inch
38	129-0036-00	101	1759	2	POST, binding, black
	129-0063-00	1760		2	POST, binding, charcoal
	- - - - - -			-	mounting hardware for each: (not included w/post)
	358-0036-00	101	1759	1	BUSHING, binding post, black
	358-0169-00	1760		1	BUSHING, binding post, charcoal
	210-0445-00	101	1119	2	NUT, hex., 10-32 x $^{3}/_{8}$ inch
	220-0410-00	1120		1	NUT, keps, 10-32 x $^{3}/_{8}$ inch
	210-0010-00	101	1119X	1	LOCKWASHER, internal, #10
	210-0206-00	101	1119X	1	LUG, solder, SE #10
39	136-0047-00			1	SOCKET, light
	210-0255-00	X1670		1	LUG, solder, $^{3}/_{8}$ inch
40	136-0106-00	101	418	3	SOCKET, banana jack, black
	136-0138-00	419	1759	3	SOCKET, banana jack, black
	136-0140-00	1760		3	SOCKET, banana jack, charcoal
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	210-0895-00			1	WASHER, insulating, shouldered
	210-0465-00			2	NUT, hex., $^{1}/_{4}$-32 x $^{3}/_{8}$ inch
	210-0223-00			1	LUG, solder, $^{1}/_{4}$ inch
41	406-0596-00			1	BRACKET, switch, sweep time/cm
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x $^{5}/_{16}$ inch, BHS
42	366-0038-00			1	KNOB, small red — VARIABLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS
43	366-0058-00	101	1759	1	KNOB, large black — SWEEP TIME/CM
	366-0144-00	1760		1	KNOB, large charcoal—SWEEP TIME/CM
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
44	262-0353-00			1	SWITCH, wired — SWEEP TIME/CM (See Ref. #53 & #54)
	- - - - - -			-	switch includes:
	260-0327-00			1	SWITCH, unwired — SWEEP TIME/CM
45	179-0450-00			1	CABLE HARNESS, time/cm switch
46	384-0209-00			1	ROD, extension
	376-0014-00			1	COUPLING, pot
47	348-0003-00			2	GROMMET, 5/16 inch
48	385-0075-00	101	329	1	ROD, nylon
	385-0135-00	330		1	ROD, delrin
	- - - - - -			-	mounting hardware: (not included w/rod alone)
	211-0507-00	101	329	1	SCREW, 6-32 x 5/16 inch, BHS
	213-0054-00	330		1	SCREW, thread cutting, 6-32 x 5/16 inch, PHS phillips
49	348-0031-00			2	GROMMET, 3/32 inch
50	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot alone)
	210-0413-00			2	NUT, hex., 3/8-32 x 1/2 inch
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
51	406-0603-00			1	BRACKET, timing capacitor
52	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor alone)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
	- - - - - -			-	mounting hardware: (not included w/switch)
53	211-0029-00			2	SCREW, 5-40 x 3/16 inch, PHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE #4
54	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
55	366-0042-00	101	1759	1	KNOB, large black — VARIABLE
	366-0117-00	1760		1	KNOB, large charcoal—VARIABLE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
56	129-0051-00			2	POST, binding
	- - - - - -			-	each post includes:
	355-0507-00			1	STEM, adapter
	200-0182-00			1	CAP
	- - - - - -			-	mounting hardware for each: (not included w/post)
	210-0223-00			1	LUG, solder, 1/4 inch
	210-0455-00			1	NUT, hex., 1/4-28 x 3/8 inch
57	260-0251-00	101	1759	1	SWITCH, slide — SOURCE
	260-0450-00	1760		1	SWITCH, slide—SOURCE
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
58	260-0145-00	101	1759	1	SWITCH, slide — COUPLING
	260-0449-00	1760		1	SWITCH, slide—COUPLING
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
59	260-0212-00	101	1759	1	SWITCH, slide — SLOPE
	260-0447-00	1760		1	SWITCH, slide—SLOPE
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
60	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot)
	210-0429-00			1	NUT, hex., 3/8-32 x 1/2 x 1 1/16 inches
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	358-0010-00			1	BUSHING, 3/8-32 x 9/16 inch
61	136-0035-00			2	SOCKET, graticule light
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	211-0534-00			1	SCREW, 6-32 x 5/16 inch, PHS w/lockwasher
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
62	406-0239-00			3	BRACKET, CRT spring
63	387-0263-00			1	PLATE, front subpanel
64	124-0022-00			1	STRIP, felt
65	337-0381-00			1	SHIELD, aluminum
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, BHS
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
66	337-0380-00			1	SHIELD, focus and intensity
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, BHS
	211-0538-00			1	SCREW, 6-32 x 5/16 inch, FHS phillips
67	348-0005-00	101	1440	1	GROMMET, 1/2 inch
	252-0562-00	1441		FT	STRIP, polyethylene extruded channel (1 9/16 inches)
68	343-0002-00			1	CLAMP, cable, 3/16 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
	211-0511-00			1	SCREW, 6-32 x 1/2 inch, BHS
	210-0803-00			2	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
69	387-0267-00			1	PLATE, dust cover, top
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0541-00			8	SCREW, 6-32 x 1/4 inch, FHS phillips
70	343-0042-00			2	CLAMP, cable, 5/16 inch (half)
	- - - - - -			-	mounting hardware for each: (not included w/clamp)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
71	337-0379-00			1	SHIELD, CRT
	- - - - - -			-	mounting hardware: (not included w/shield)
72	211-0513-00			1	SCREW, 6-32 x 5/8 inch, BHS
	210-0006-00			1	LOCKWASHER, internal, #6
	166-0107-00			1	TUBE, spacing
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
73	210-0006-00			5	LOCKWASHER, internal, #6
	210-0407-00			5	NUT, hex., 6-32 x 1/4 inch
74	175-0582-00			1	WIRE, CRT lead, .458 foot, striped brown w/connector
	175-0583-00			1	WIRE, CRT lead, 11 1/2 inches, striped red w/connector
	175-0584-00			1	WIRE, CRT lead, 11 1/2 inches, striped green w/connector
	175-0596-00			1	WIRE, CRT lead, .417 foot, striped blue w/connector
75	387-0271-00			1	PLATE, side, left
76	354-0078-00	101	529	1	RING, CRT rotator
	354-0178-00	530		1	RING, CRT rotator
77	406-0601-00			1	BRACKET, CRT shield
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			4	SCREW, 6-32 x 5/16 inch, BHS
	210-0202-00			1	LUG, solder, SE #6
78	432-0022-00			1	BASE, CRT rotator
	- - - - - -			-	mounting hardware: (not included w/base)
	211-0561-00			2	SCREW, 6-32 x 3/8 inch, Hex. FH cap
79	210-0503-00			1	NUT, CRT rotator securing
80	355-0049-00			1	STUD, CRT rotator
81	366-0032-00			1	KNOB, small red
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
82	211-0560-00			1	SCREW, 6-32 x 1 inch, RHS
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
83	354-0103-00			1	RING, clamping
	- - - - - -			-	ring includes:
	210-0502-00			1	NUT, CRT rotator
84	136-0076-00	101	328	1	SOCKET, CRT
	387-0344-00	101	328	1	PLATE, CRT socket back
	211-0038-00	101	328	2	SCREW, 4-40 x 5/16 inch, 100° csk, FHS
	136-0113-00	329		1	ASSEMBLY, CRT socket
	- - - - - -			-	assembly includes:
	136-0117-00			1	SOCKET, CRT
	131-0178-00			9	CONNECTOR, cable end, CRT
	387-0393-00			1	PLATE, back, CRT socket
	- - - - - -			-	mounting hardware: (not included w/plate alone)
	213-0086-00			2	SCREW, thread cutting, 2-32 x 7/16 inch, PHS
85	- - - - - -			1	TRANSFORMER
	- - - - - -			-	transformer includes:
	212-0517-00			4	SCREW, 10-32 x 1 3/4 inches, HHS
	210-0812-00			4	WASHER, fiber, #10
	220-0410-00			4	NUT, keps, 10-32 x 3/8 inch

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EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
86	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
	386-0253-00			1	PLATE, metal, small capacitor
	211-0534-00			2	SCREW, 6-32 x 5/16 inch, PHS w/lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
87	200-0256-00			1	COVER, capacitor
88	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
	386-0252-00			1	PLATE, fiber, small capacitor
	211-0534-00			2	SCREW, 6-32 x 5/16 inch, PHS w/lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
89	348-0004-00			1	GROMMET, 3/8 inch
90	337-0008-00			1	SHIELD, tube
91	136-0022-00			1	SOCKET, STM9S
	- - - - - -			-	mounting hardware: (not included w/socket)
	211-0033-00			2	SCREW, 4-40 x 5/16 inch, PHS w/lockwasher
	210-0201-00			1	LUG, solder, SE #4
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
92	136-0095-00	101	1389	2	SOCKET, 4 pin transistor
	136-0182-00	1390		2	SOCKET, 4 pin transistor
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0113-00	101	1389	2	SCREW, thread forming, 2-32 x 5/16 inch, RHS phillips
	354-0234-00	1390		1	RING, locking, transistor socket
93	136-0008-00			5	SOCKET, STM7G
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch, PHS phillips
94	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 3/16 inch, PHS phillips
95	348-0031-00			6	GROMMET, 3/32 inch
96	348-0003-00			7	GROMMET, 5/16 inch
97	136-0015-00			7	SOCKET, STM9G
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch, PHS phillips
98	387-0268-00			1	PLATE, dust cover, bottom
	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0541-00			10	SCREW, 6-32 x 1/4 inch, FHS phillips
99	387-0270-00			1	PLATE, side, right

EXPLODED VIEW *(Cont'd)*

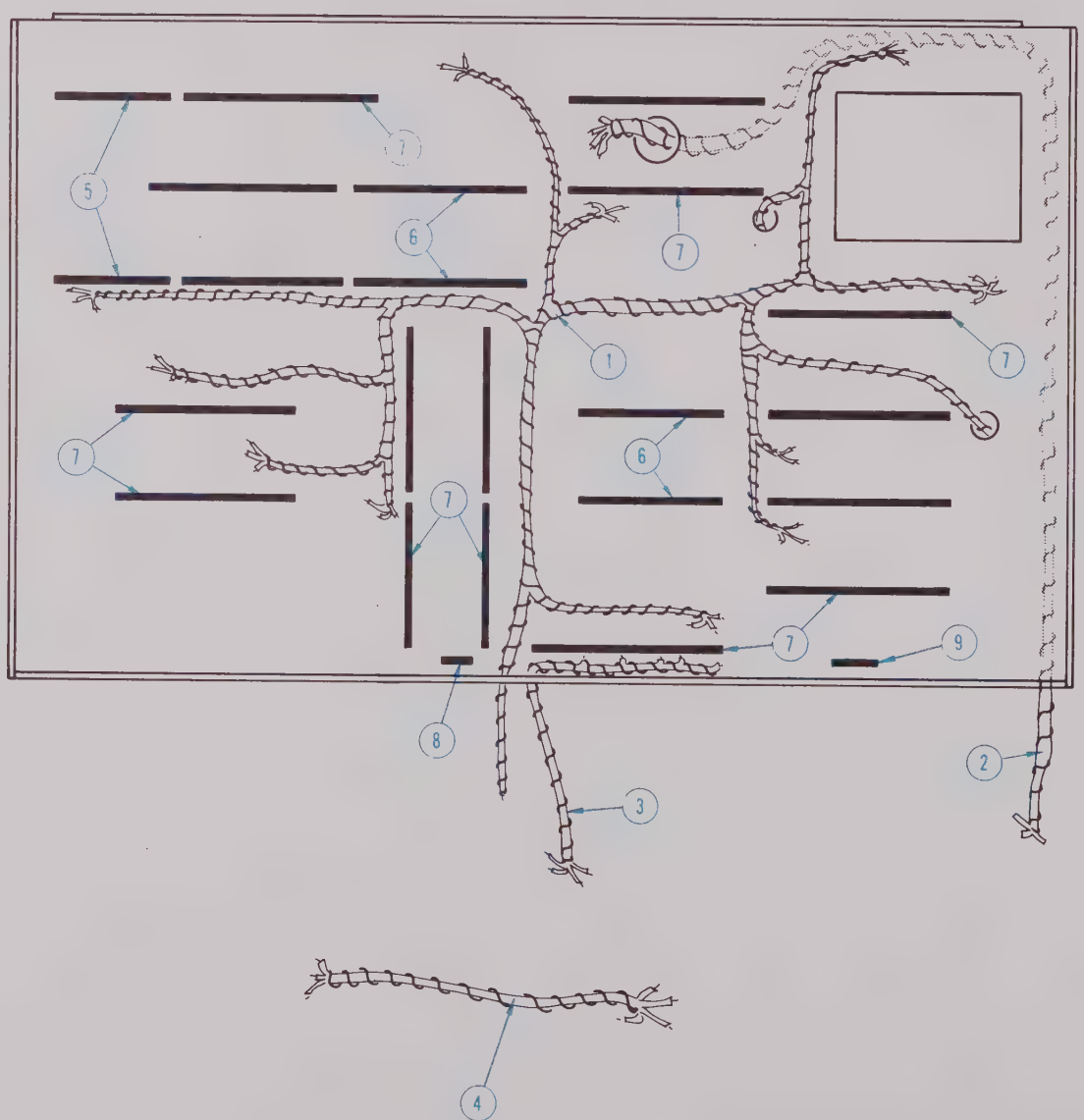
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
100	385-0073-00	101	329	1	ROD, nylon
	385-0134-00	330		1	ROD, delrin
	- - - - - -			-	mounting hardware: (not included w/rod)
	211-0507-00	101	329	1	SCREW, 6-32 x 5/16 inch, BHS
	213-0054-00	330		1	SCREW, thread cutting, 6-32 x 5/16 inch, PHS phillips
101	200-0247-00	101	919X	7	COVER, pot
102	214-0210-00	X329		1	SPOOL, solder, assembly
	- - - - - -			-	spool includes:
	214-0209-00			1	SPOOL, solder
	- - - - - -			-	mounting hardware: (not included w/spool)
	361-0007-00			1	SPACER, nylon, .063 inch
103	385-0147-00			2	ROD, support
	- - - - - -			-	mounting hardware for each: (not included w/rod)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, BHS
104	260-0336-00			1	SWITCH, thermal cut-out
	- - - - - -			-	mounting hardware: (not included w/switch)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch, PHS phillips
105	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	386-0255-00			1	PLATE, metal, large capacitor
	211-0534-00			2	SCREW, 6-32 x 5/16 inch, PHS w/lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
106	441-0329-00			1	CHASSIS, main
	- - - - - -			-	mounting hardware: (not included w/chassis)
	212-0004-00			13	SCREW, 8-32 x 5/16 inch, BHS
107	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	386-0254-00			1	PLATE, fiber, large capacitor
	211-0543-00			2	SCREW, 6-32 x 5/16 inch, RHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
108	200-0258-00			1	COVER, capacitor
109	- - - - - -			7	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0840-00	X920		1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00	X920		1	NUT, hex., 3/8-32 x 1/2 inch
110	136-0106-00	101	418	1	SOCKET, banana jack, black
	136-0138-00	419	1759	1	SOCKET, banana jack, black
	136-0140-00	1760		1	SOCKET, banana jack, charcoal
	- - - - - -			-	mounting hardware: (not included w/socket)
	210-0223-00			1	LUG, solder, 1/4 inch
	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
111	131-0142-00			1	CONNECTOR, cable end, tube

©

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
112	136-0011-00			1	SOCKET, STM8
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch, PHS phillips
113	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: (not included w/transformer)
	211-0504-00			4	SCREW, 6-32 x 1/4 inch, BHS
114	134-0012-00			1	PLUG, banana
115	387-0269-00			1	PLATE, back
	- - - - - -			-	mounting hardware: (not included w/plate)
	212-0004-00			6	SCREW, 8-32 x 5/16 inch, BHS
	212-0040-00			4	SCREW, 8-32 x 3/8 inch, FHS phillips
	210-0008-00			4	LOCKWASHER, internal, #8
	210-0409-00			4	NUT, hex., 8-32 x 5/16 inch
116	334-0649-00			1	TAG, voltage rating
	- - - - - -			-	mounting hardware: (not included w/tag)
	213-0088-00			2	SCREW, thread forming, 4-40 x 1/4 inch, PHS phillips
117	131-0102-00			1	CONNECTOR, 3 wire, motor base (See Ref. #119)
	- - - - - -			-	connector includes:
	129-0041-00			1	POST, ground
	200-0185-00			1	COVER, motor base
	210-0003-00			2	LOCKWASHER, external, #4
	210-0551-00			2	NUT, hex., 4-40 x 1/4 inch
	211-0015-00			1	SCREW, 4-40 x 1/2 inch, RHS
	214-0078-00			2	PIN, connecting
	377-0041-00			1	INSERT, black urea
118	386-0933-00			1	PLATE, motor base
	- - - - - -			-	mounting hardware: (not included w/connector)
119	211-0545-00			2	SCREW, 6-32 x 1 1/4 inches, THS phillips
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
120	361-0012-00			1	SPACER, motor base
121	200-0256-00	101	1769	1	COVER, capacitor, 2 1/32 inches
	200-0532-00	1770		1	COVER, capacitor, 1 19/32 inches

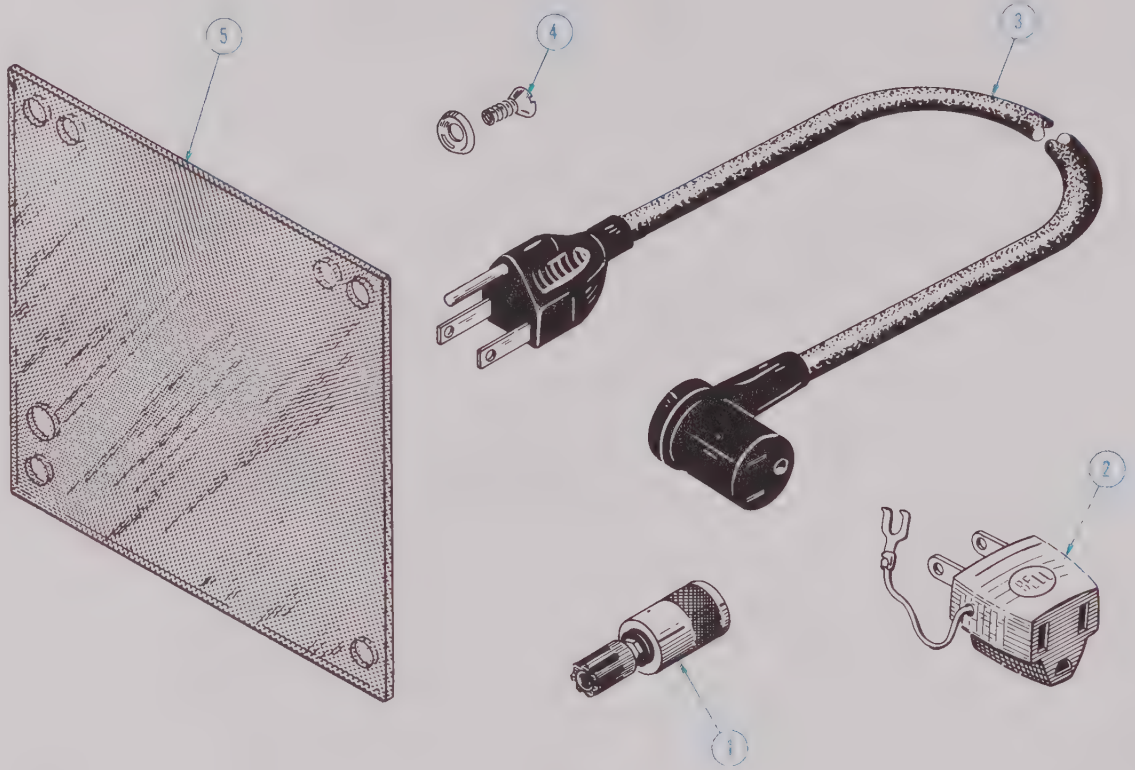
CABLE HARNESS & CERAMIC STRIP DETAIL



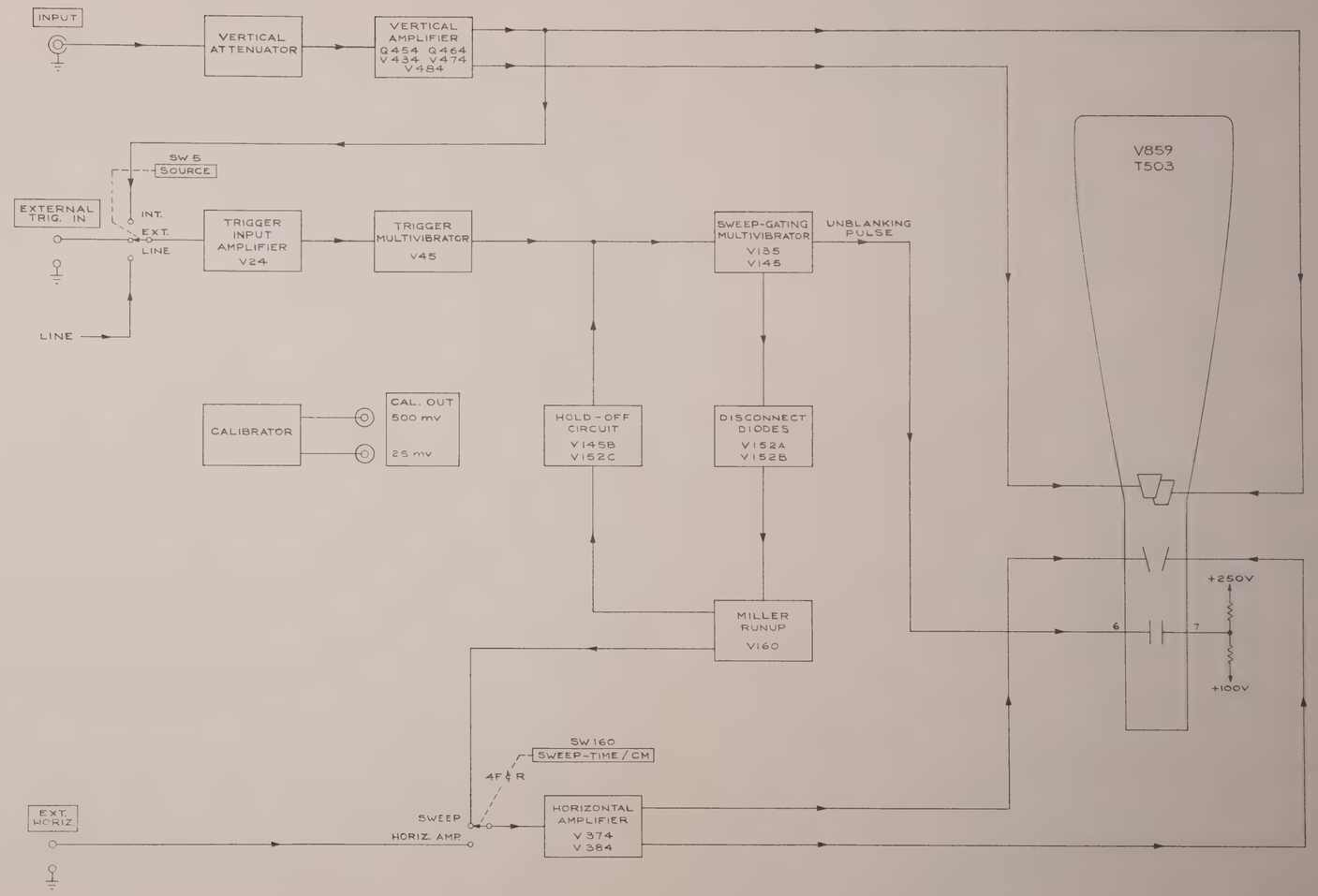
CABLE HARNESS & CERAMIC STRIP DETAIL

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	179-0448-00			1	CABLE HARNESS, chassis
2	179-0447-00			1	CABLE HARNESS, focus and intensity
3	179-0449-00			1	CABLE HARNESS, subpanel #1
4	179-0446-00			1	CABLE HARNESS, subpanel #2
5	124-0089-00			2	STRIP, ceramic, 3/4 inch x 7 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, nylon, .313 inch
6	124-0090-00			4	STRIP, ceramic, 3/4 inch x 9 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, nylon, .313 inch
7	124-0091-00			16	STRIP, ceramic, 3/4 inch x 11 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, nylon, .313 inch
8	124-0119-00			1	STRIP, ceramic, 7/16 inch x 2 notches
	- - - - - -			-	strip includes:
	355-0046-00			1	STUD, nylon
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0007-00			1	SPACER, nylon, .063 inch
9	124-0088-00			1	STRIP, ceramic, 3/4 inch x 4 notches
	- - - - - -			-	strip includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0009-00			2	SPACER, nylon, .313 inch

STANDARD ACCESSORIES

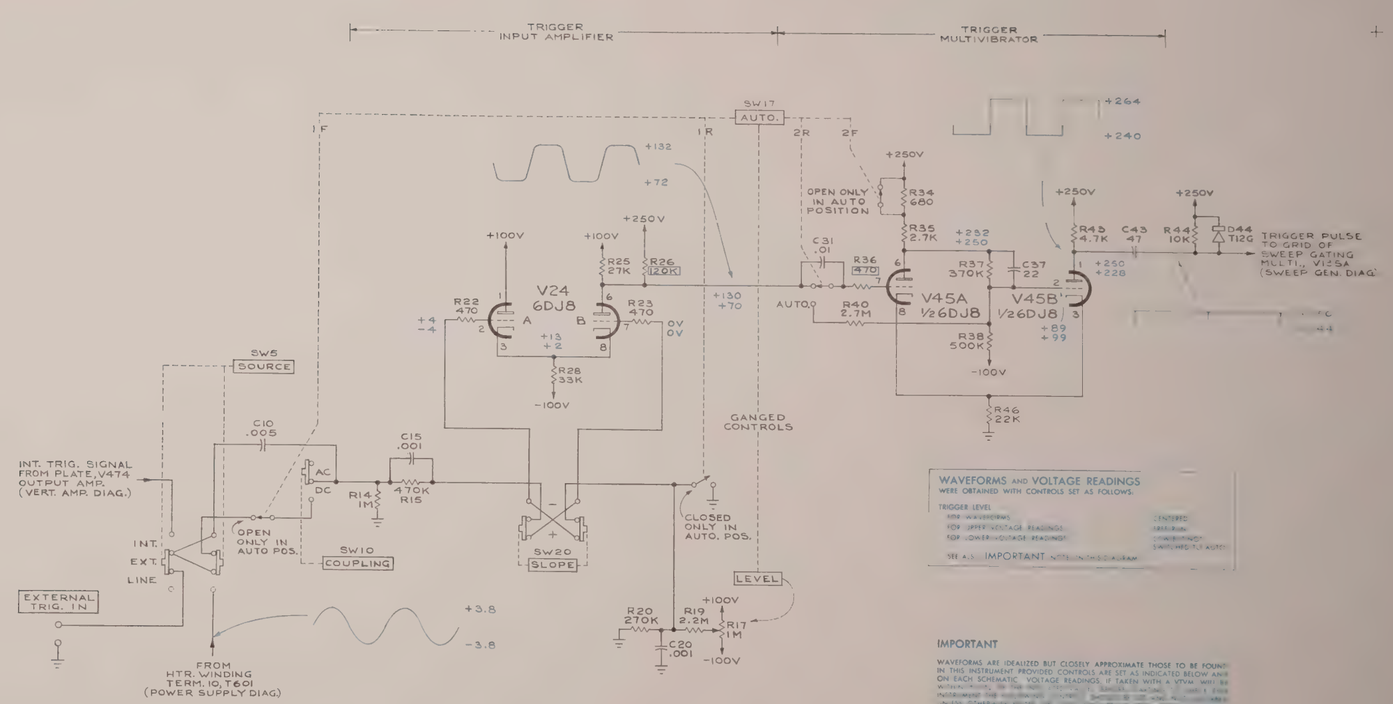


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
-	070-0315-00			1	MANUAL, instruction (not shown)
1	013-0004-00			1	ADAPTER, binding post
2	103-0013-00			1	ADAPTER, power cord
3	161-0010-00	101	567	1	CORD, power
	161-0013-00	568	1359	1	CORD, power
	161-0022-00	1360	1806	1	CORD, power
	161-0024-00	1807	2379	1	CORD, power
	161-0024-01	2380		1	CORD, power
4	210-0833-00			4	WASHER, finishing, #10
	210-0917-00			4	WASHER, teflon
	212-0512-00			4	SCREW, 10-32 x ½ inch, OHS
	212-0561-00			4	SCREW, 12-24 x ½ inch, OHS
5	378-0514-00	X469	1849	1	FILTER, light
	378-0567-00	1850		1	FILTER, light, smoke gray



MRH
12-6-62

BLOCK DIAGRAM



TYPE RM504 OSCILLOSCOPE

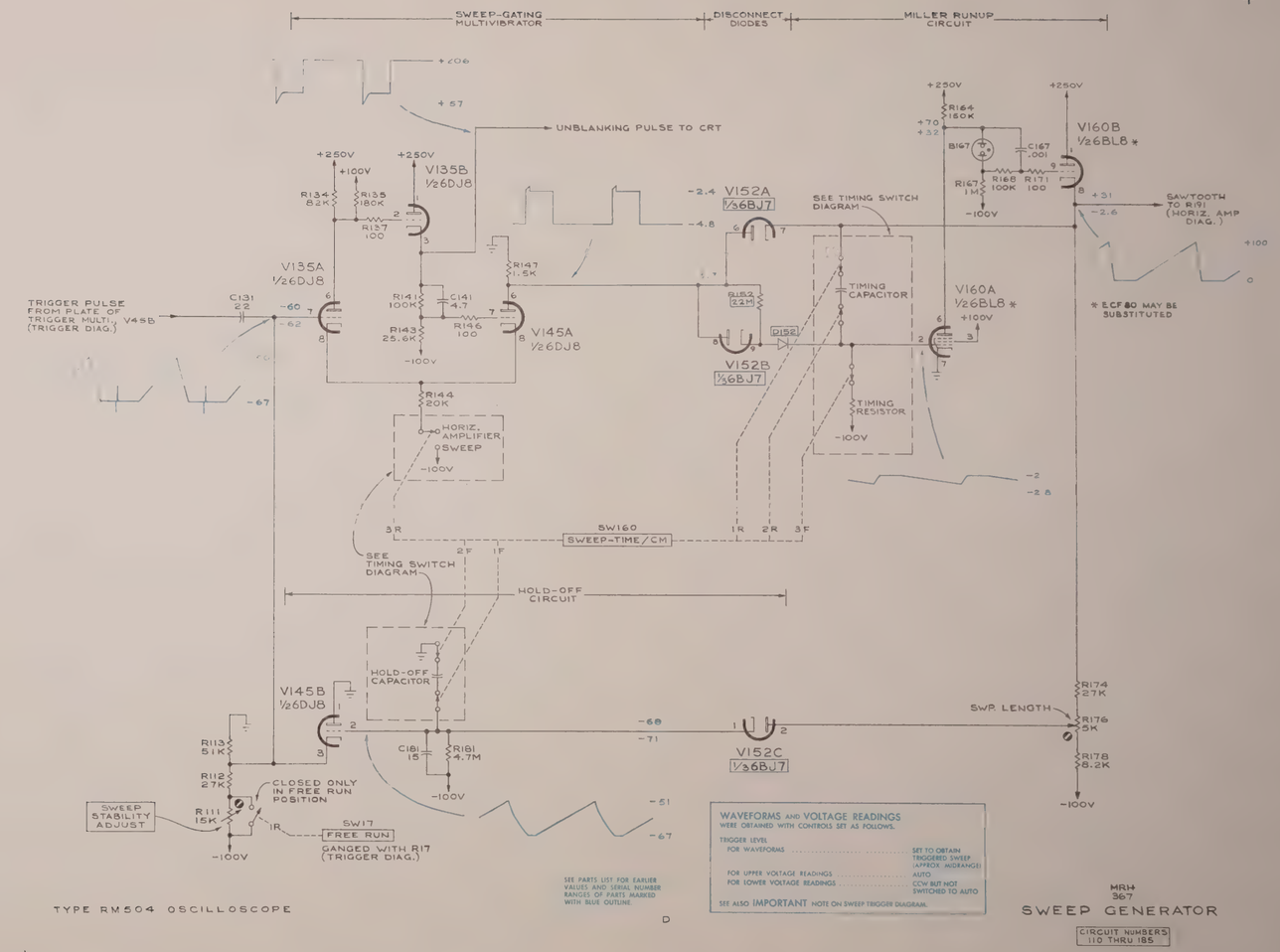
A2

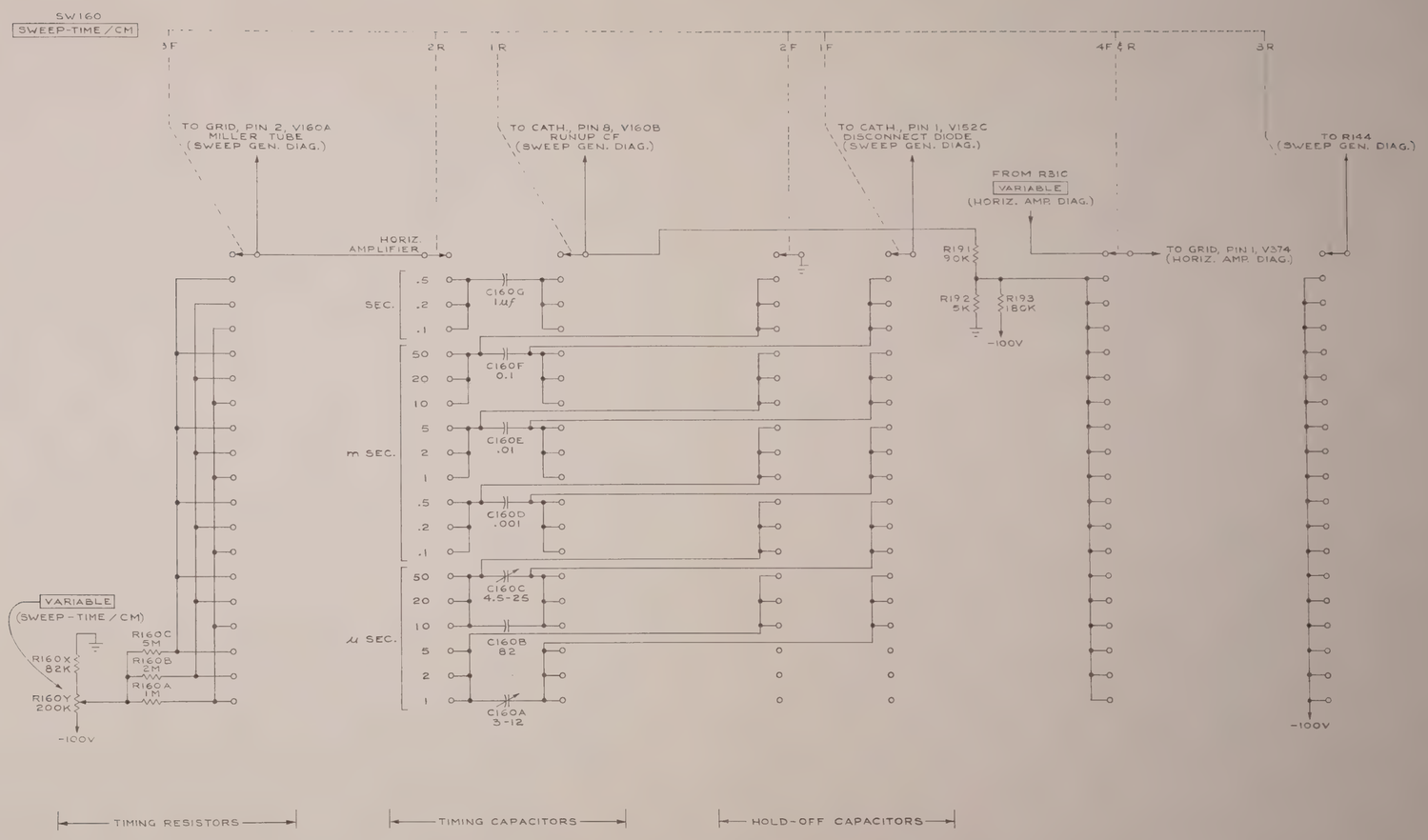
MRH
964

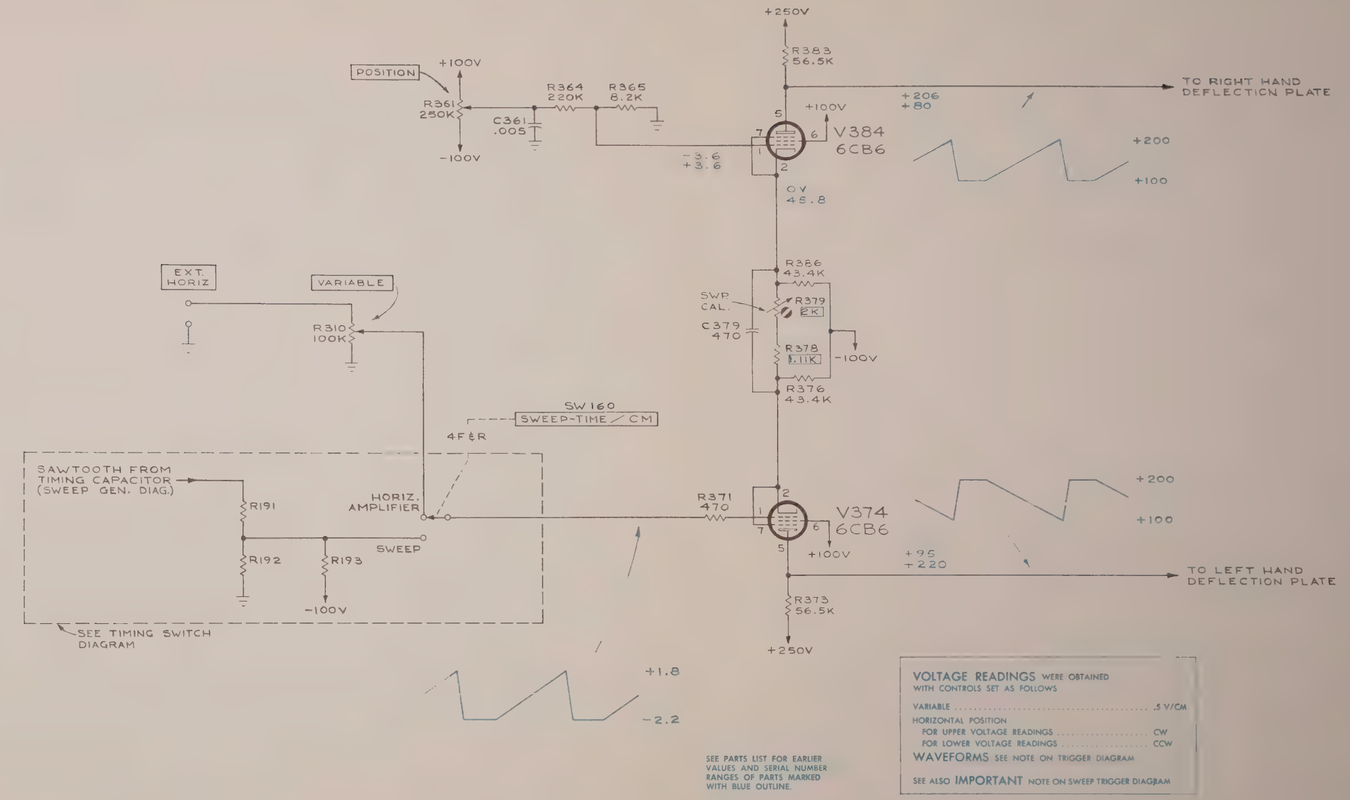
SWEEP TRIGGER

CIRCUIT NUMBERS
1 THRU 49

SWEEP TRIGGER


SWEEP-GATING MULTIVIBRATOR
DISCONNECT DIODES
MILLER RUNUP CIRCUIT
+206
+57
UNBLANKING PULSE TO CRT
+250V
+100V
V135B
½6DJ8
R134 82K
R135 180K
R137 100
V135A
½6DJ8
R147 1.5K
C131 22
-60
-62
-67
TRIGGER PULSE FROM PLATE OF TRIGGER MULTI., V45B (TRIGGER DIAG.)
R141 100K
C141 4.7
R146 100
R143 25.6K
-100V
V145A
½6DJ8
R144 20K
HORIZ. AMPLIFIER
SWEEP
-100V
-2.4
V152A
½6BJ7
-4.8
SEE TIMING SWITCH DIAGRAM
TIMING CAPACITOR
TIMING RESISTOR
-100V
G152 22M
D152
V152B
½6BJ7
+250V
R164 160K
+70
+32
B167
C167 .001
R167 1M
R168 100K
R171 100
-100V
V160B
½26BL8 *
+31
-2.6
SAWTOOTH TO R191 (HORIZ. AMP DIAG.)
+100
0
V160A
½26BL8 *
+100V
* ECF80 MAY BE SUBSTITUTED
-2
-2.8
3R
SW160
SWEEP-TIME/CM
1R 2R 3F
2F 1F
SEE TIMING SWITCH DIAGRAM
HOLD-OFF CIRCUIT
HOLD-OFF CAPACITOR
V145B
½6DJ8
R113 51K
R112 27K
R111 15K
SWEEP STABILITY ADJUST
CLOSED ONLY IN FREE RUN POSITION
1R
SW17
FREE RUN
GANGED WITH R17 (TRIGGER DIAG.)
-100V
C181 15
R181 4.7M
-68
-71
V152C
½6BJ7
-51
-67
SWP. LENGTH
R174 27K
R176 5K
R178 8.2K
-100V
WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS.
TRIGGER LEVEL
FOR WAVEFORMS ..... SET TO OBTAIN TRIGGERED SWEEP (APPROX. MIDRANGE)
FOR UPPER VOLTAGE READINGS ..... AUTO
FOR LOWER VOLTAGE READINGS ..... CCW BUT NOT SWITCHED TO AUTO
SEE ALSO IMPORTANT NOTE ON SWEEP TRIGGER DIAGRAM.
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
D
TYPE RM504 OSCILLOSCOPE
MRH 367
SWEEP GENERATOR
CIRCUIT NUMBERS 110 THRU 185


SW160
SWEEP-TIME/CM
5F
2R
1R
2F
1F
4F & R
3R
TO GRID, PIN 2, V160A
MILLER TUBE
(SWEEP GEN. DIAG.)
TO CATH, PIN 8, V160B
RUNUP CF
(SWEEP GEN. DIAG.)
TO CATH., PIN 1, V152C
DISCONNECT DIODE
(SWEEP GEN. DIAG.)
TO R144
(SWEEP GEN. DIAG.)
FROM R31C
VARIABLE
(HORIZ. AMP. DIAG.)
HORIZ.
AMPLIFIER
R191
90K
TO GRID, PIN 1, V374
(HORIZ. AMP. DIAG.)
R192
5K
R193
180K
-100V
SEC.
.5
.2
.1
C160G
1 uf
50
20
10
5
2
1
m SEC.
C160F
0.1
C160E
.01
C160D
.001
50
20
10
5
2
1
u SEC.
C160C
4.5-25
C160B
82
C160A
3-12
VARIABLE
(SWEEP-TIME/CM)
R160C
5M
R160B
2M
R160A
1M
R160X
82K
R160Y
200K
-100V
TIMING RESISTORS
TIMING CAPACITORS
HOLD-OFF CAPACITORS



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS

VARIABLE ..... .5 V/CM
HORIZONTAL POSITION
FOR UPPER VOLTAGE READINGS ..... CW
FOR LOWER VOLTAGE READINGS ..... CCW

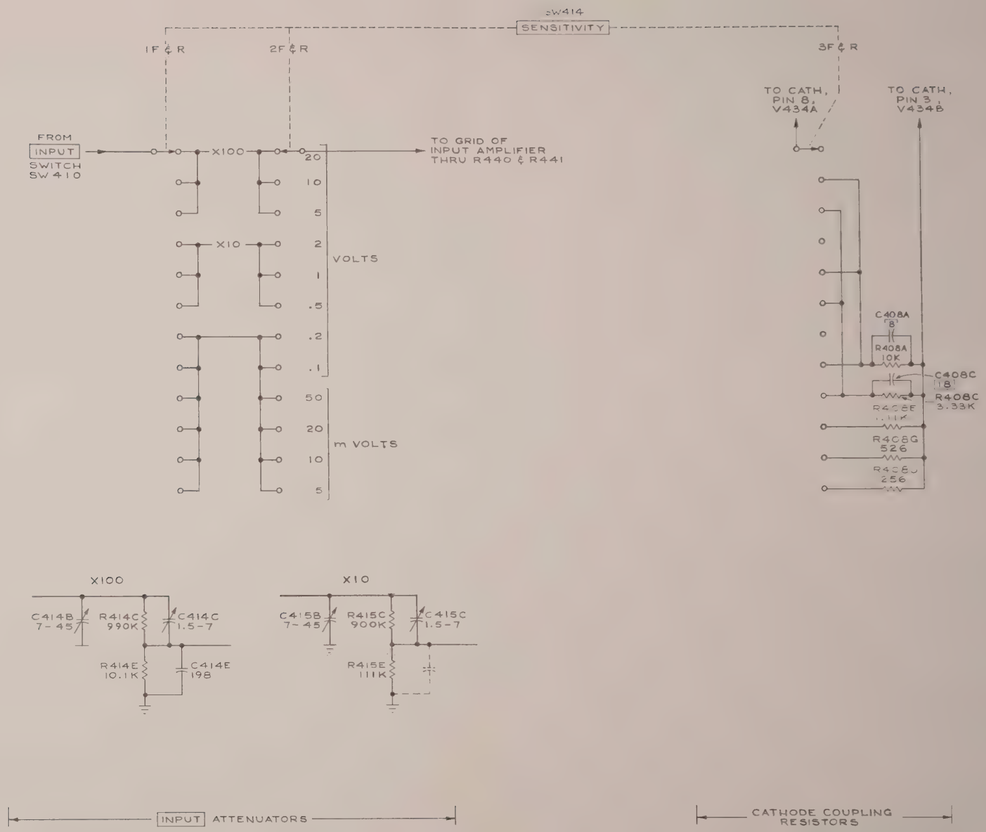
WAVEFORMS SEE NOTE ON TRIGGER DIAGRAM

SEE ALSO **IMPORTANT** NOTE ON SWEEP TRIGGER DIAGRAM

MRH
964

HORIZONTAL AMPLIFIER

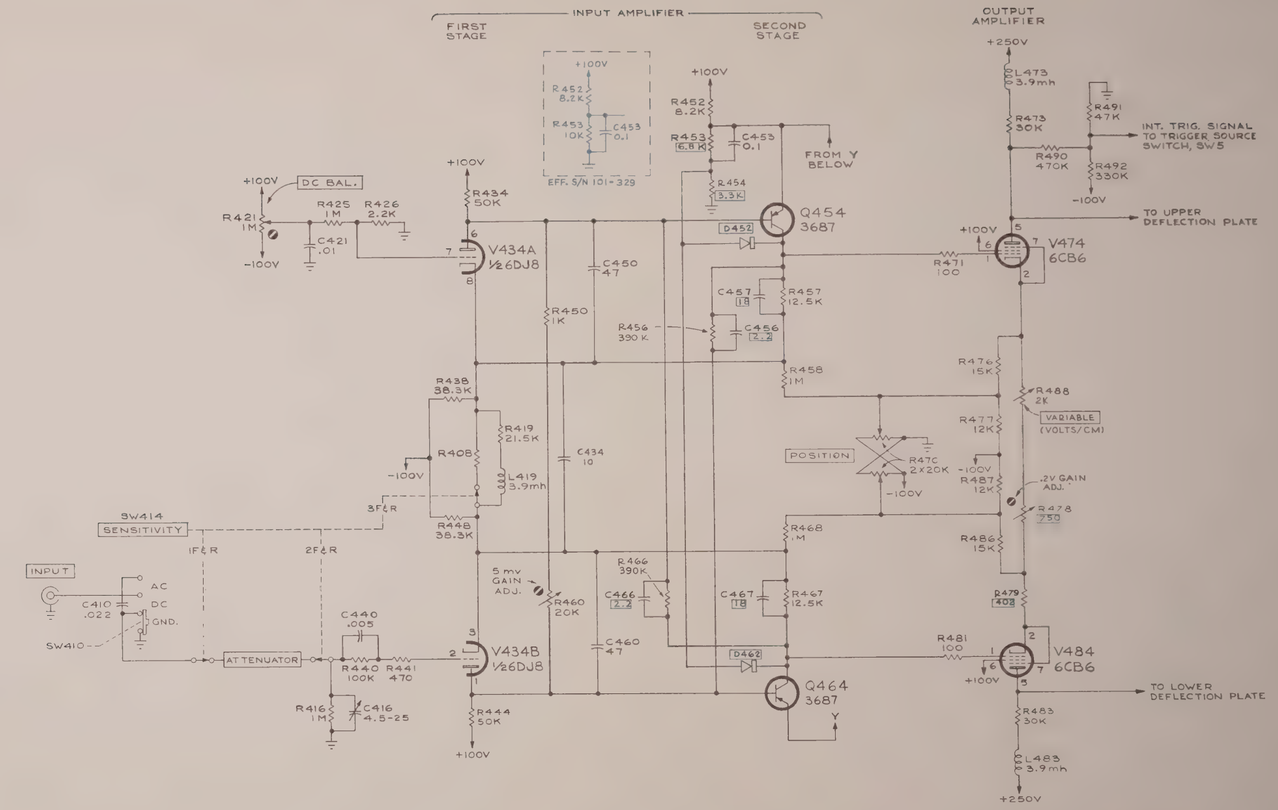
CIRCUIT NUMBERS 300 THRU 399



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE

MRH
964

VERTICAL AMPLIFIER ATTENUATOR SWITCH

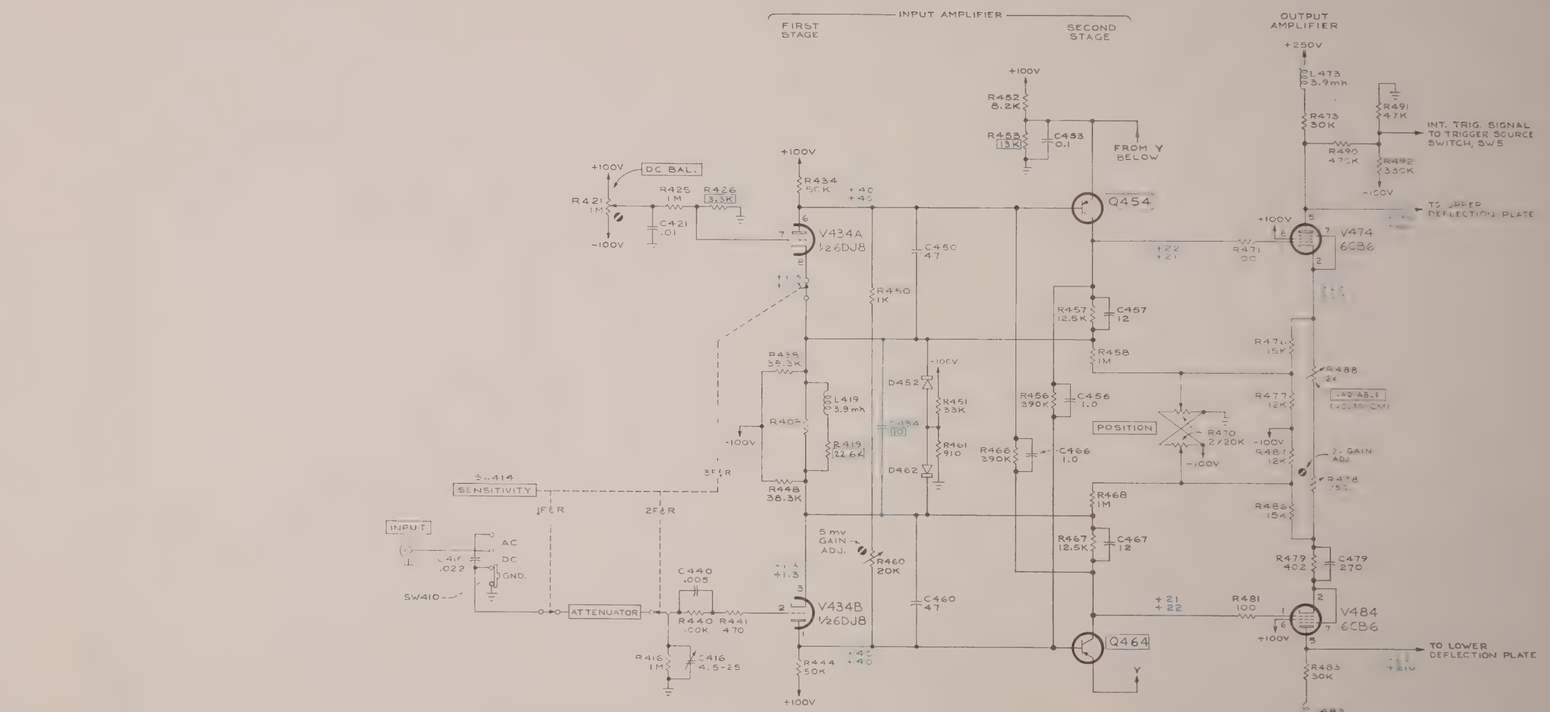


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE

MRH
964

VERTICAL AMPLIFIER

EFF. S/N 101-439



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

BOTH INPUTS	GND
SENSITIVITY	2 VOLTS/CM
VERTICAL POSITION	
FOR UPPER VOLTAGE READINGS	CW
FOR LOWER VOLTAGE READINGS	CCW

SEE ALSO IMPORTANT NOTE ON SWEEP TRIGGER DIAGRAM

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

MRH 567

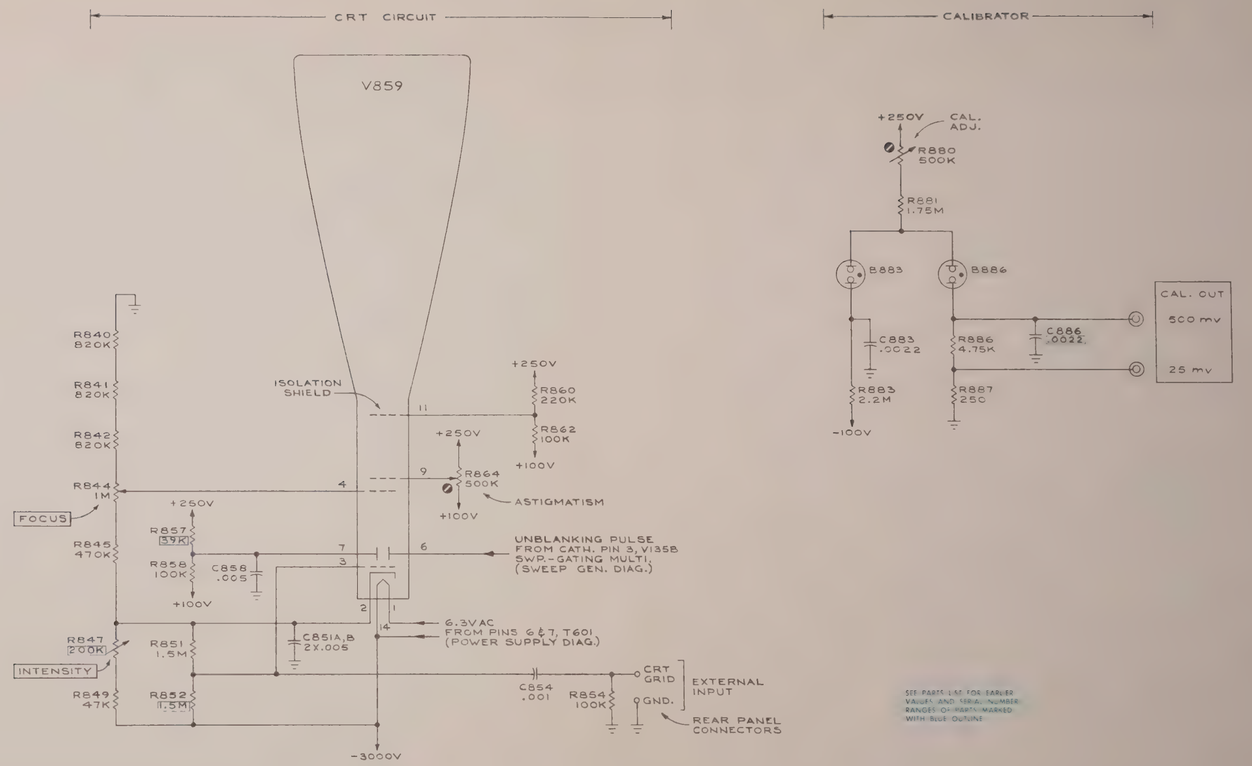
TYPE RM504 OSCILLOSCOPE

C

VERTICAL AMPLIFIER

S/N 440 - UP

CIRCUIT NUMBERS 400 THRU 499

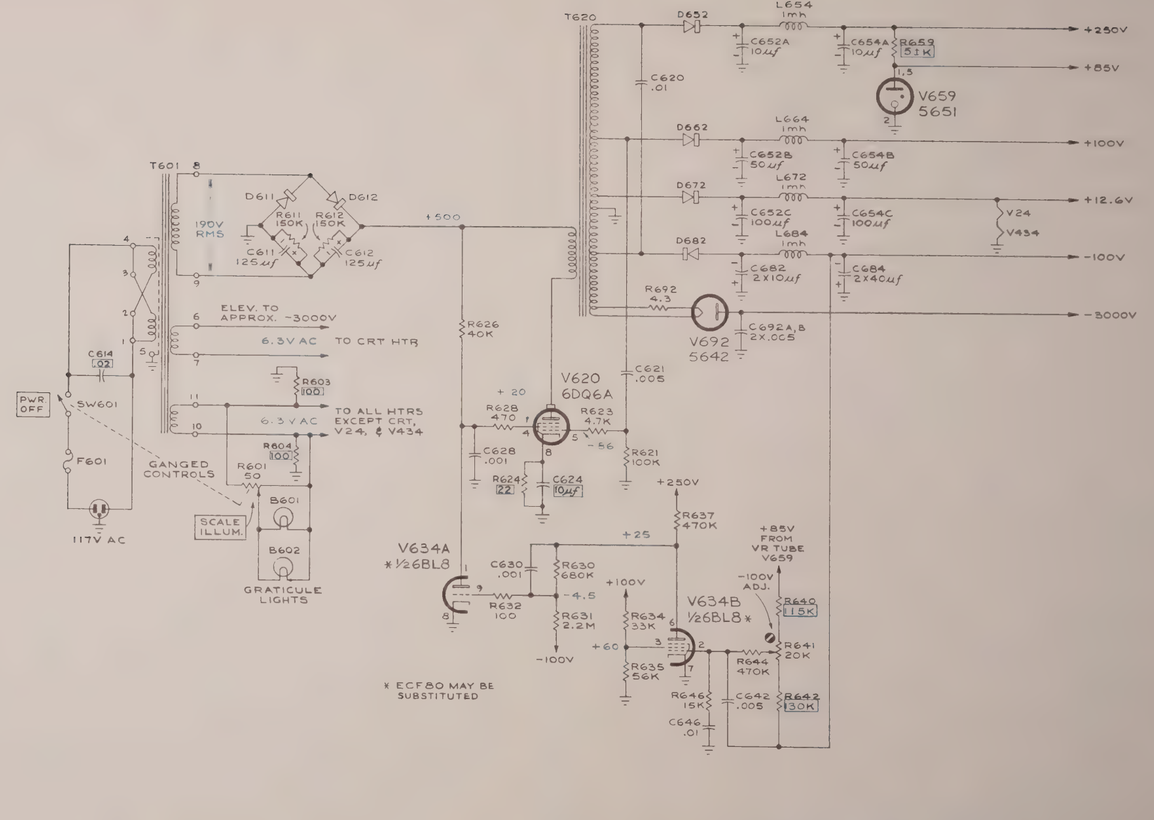


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE

MRH
9-64

CRT CIRCUIT & CALIBRATOR

CIRCUIT NUMBERS 540 THRU 569



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS

LINE VOLTAGE ..... 117 V 60 CPS

TRIGGER LEVEL (SWEEP DISABLED) ..... CCW BUT NOT SWITCHED TO AUTO

SEE ALSO **IMPORTANT** NOTE ON SWEEP TRIGGER DIAGRAM

MRH
366

POWER SUPPLY

CIRCUIT NUMBERS
600 THRU 699

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

TYPE RM504 TENT SN 2620

PARTS LIST CORRECTION

CHANGE TO:

C160D C160E C160F C160G	295-0109-00			
SW160	262-0353-01 (wired)	Rotary	TIME/CM	

M12,347/1167

TYPE RM504 TENT SN 2550

PARTS LIST CORRECTION

CHANGE TO:

D611	152-0040-00	Silicon 1N2615
D612	152-0040-00	Silicon 1N2615

M12,081/967

TYPE RM504 TENT SN 2300

PARTS LIST CORRECTION

ADD:

R152	316-0226-00	22 meg	1/4 w	10 %

R152 is added in parallel with V152B; pins 8 - 9.

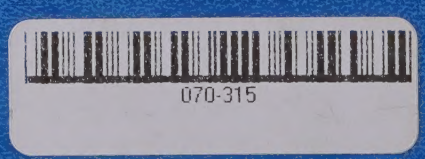
TYPE RM504

TENT SN 2380

PARTS LIST CORRECTION

CHANGE TO:

R426	302-0332-00	3.3 k	1/2 W	10 %
R453	301-0133-00	13 k	1/2 W	5 %


070-315